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OCTOBER '85

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COVER 1

Is there a variable power supply on your electronics workbench? Then consider building one like the one shown on our cover. It has three pairs of complementary outputs: the first pair is dual-tracking, while the outputs of the second pair are independently adjustable. The third pair is used as a precision voltage reference.

The supply is versatile and easy to build. We'll show you how to increase its current capacity, and how to build it with only the outputs you need. For more information, see page 53.

NEXT MONTH

THE NOVEMBER ISSUE IS ON SALE OCTOBER 3

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Now you can superimpose titles and symbols directly over video images!

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Electromagnetic interference, its causes, and its cures.

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It will become increasingly important to know how.

HOW TO DESIGN WITH DIGITAL IC'S
All about digital counters.

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NEW! Uniden® Bearcat® Regency®

Scanners

Communications Electronics™, the world's largest distributor of radio scanners, introduces new scanners and scanner accessories from J.I.L., Regency and also Uniden/Bearcat. Chances are the police, fire and weather emergencies you'll read about in tomorrow's paper are coming through on a scanner today.

NEW! Regency‡ MX7000-K

List price $699.95/**CE price $429.00/SPECIAL**
10-Band, 20 Channel • Crystalless • AC/DC
Frequency range: 25-550 MHz. continuous coverage and 800 MHz. to 1.2 GHz. continuous coverage
In addition to normal scanner listening, the MX7000 offers CB, VHF, and UHF TV audio, FM Broadcast, all aircraft bands (civil and military), 800 MHz communications, cellular telephone, and when connected to a printer or CRT, satellite weather pictures.

NEW! Regency® MX5000-K

List price $599.95/**CE price $329.00/SPECIAL**
Multi-Band, 20 Channel • No-crystal scanner
Search • Lockout • Priority • AC/DC
Selectable AM-FM modes • LCD display
World's first continuous coverage scanner
Frequency range: 25-550 MHz. continuous coverage.
Never before have so many features come in such a small package. The *Regency* MX5000 mobile or home scanner has continuous coverage from 25 to 550 MHz. That means you can hear CB, Television audio, FM broadcast stations, all aircraft bands including military and the normal scanner bands, all on your choice of 20 programmable channels.

NEW! Regency® MX4000-K

List price $629.95/**CE price $299.00/SPECIAL**
Multi-Band, 20 Channel • No-crystal scanner
Search • Lockout • Priority • AC/DC
Selectable AM-FM modes • LCD display
Bands: 30-50, 118-136, 144-174, 440-512, 800-950 MHz.
The *Regency* MX4000 is gives coverage in the standard VHF and UHF ranges with the important addition of the 800 MHz. and aircraft bands. It features keyboard entry, multifunction liquid crystal display and variable search increments.

NEW! Regency® Z60-K

List price $379.95/**CE price $216.00/SPECIAL**
8-Band, 60 Channel • No-crystal scanner
Bands: 30-50, 88-108, 118-136, 144-174, 440-512 MHz.
Cover your choice of over 15,000 frequencies on 60 channels at the touch of your finger.

NEW! JIL SX-400-K

List price $799.95/**CE price $469.00/SPECIAL**
Multi-Band, 20 Channel • No-crystal Scanner
Search • Lockout • Priority • AC/DC
Frequency range: 26-520 MHz. continuous coverage.
With optionally equipped RF converters 150KHz.-3.7 GHz.
The *JIL* SX-400 synthesized scanner is designed for commercial and professional monitor users that demand features not found in ordinary scanners. The SX-400 will cover from 150 KHz to 3.7 GHz. with RF converters. Order the following RF converters for your SX-400 scanner. **RF-1030-K** at $259.00 each for frequency range 150 KHz.-30 MHz. USB, LSB, CW and AM. (CW filter required for CW signal reception); **RF-5080-K** at $199.00 each for 500-800 MHz.; **RF-8014-K** at $199.00 each for 800 MHz.-1.4 GHz. Be sure to also order **ACB-300-K** at $99.00 each which is an antenna control box for connection of the RF converters. The **RC-4000-K** data interface at $259.00 each gives you control of the SX-400 scanner and RF converters through a computer. Add $3.00 shipping for each RF converter, data interface or antenna control box. If you need further information on the JIL scanners, contact JIL directly at 213-926-6727 or write JIL at 17120 Edwards Road, Cerritos, California 90701 U.S.A.

SPECIAL! JIL SX-200-K

List price $499.95/**CE special price $159.00**
Multi-Band - 16 Channel • No-Crystal Scanner
Frequency range 26-88, 108-180, 380-514 MHz.
The *JIL* SX-200 scanner tunes military, F.B.I., Space Satellites, Police and Fire, Drug Enforcement Agencies, Defense Department, Aeronautical AM band, Aero Navigation Band, Fish & Game, Immigration, Paramedics, Amateur Radio, Justice Department, State Department, plus other thousands of radio frequencies most other scanners can't pick up. The SX-200 has selectable AM/FM receiver circuits, tri-switch squelch settings - signal, audio and signal & audio, outboard AC power supply - DC at 12 volts built-in, quartz clock - bright vacuum fluorescent blue readouts and dimmer, dual level search speeds, tri-level scan delay switches, 16 memory channels in two channels banks, receive fine tune (RIT) ± 2KHz., dual level RF gain settings - 20 db pad, AGC test points for optional signal strength meters.

Regency® HX1000-K

List price $329.95/**CE price $209.00**
6-Band, 30 Channel • No Crystal scanner
Search • Lockout • Priority • Scan delay
Sidelit liquid crystal display • Digital Clock
Frequency range: 30-50, 144-174, 440-512 MHz.
The new handheld *Regency* HX1000 scanner is fully keyboard programmable for the ultimate in versatility. You can scan up to 30 channels at the same time. When you activate the priority control, you automatically override all other calls to listen to your favorite frequency. The LCD display is even sidelit for night use. Order **MA-256-K** rapid charge drop-in battery charger for $79.00 plus $3.00 shipping/handling. Includes wall charger, carrying case, belt clip, flexible antenna and nicad battery. Order now.

NEW! Bearcat® 100XL-K

List price $349.95/**CE price $229.00**
9-Band, 16 Channel • Priority • Scan Delay
Search • Limit • Hold • Lockout • AC/DC
Frequency range: 30-50, 118-174, 406-512 MHz.
The world's first no-crystal handheld scanner now has a LCD channel display with backlight for low light use and aircraft band coverage at the same low price. Size is 1⅜" x 7½" x 2⅞." The *Bearcat* 100XL has wide frequency coverage that includes all public service bands (Low, High, UHF and "T" bands), the AM aircraft band, the 2-meter and 70 cm. amateur bands, *plus* military and federal government frequencies. Wow...what a scanner!

Included in our low CE price is a sturdy carrying case, earphone, battery charger/AC adapter, six AA ni-cad batteries and flexible antenna. Order your scanner now.

NEW! Regency® HX2000-K

The World's First 800 MHz. Handheld Scanner
List price $569.95/**CE price $359.00**
7-Band, 20 Channel • No-crystal scanner
Priority control • Search/Scan • AC/DC
Sidelit liquid crystal display • Memory backup
Bands: 118-136, 144-174, 440-512, 800-950 MHz.
The HX2000 scanner operates on 120V AC or 6 VDC. Scans 15 channels per second. Size 3" x 7" x 1½." Includes wall charger, carrying case, belt clip, flexible antenna and nicad batteries. Selectable AM/FM modes.

NEW! Bearcat® 800XLT-K

List price $499.95/**CE price $329.00**
12-Band, 40 Channel • No-crystal scanner
Priority control • Search/Scan • AC/DC
Bands: 29-54, 118-174, 406-512, 806-912 MHz.
The Uniden 800XLT receives 40 channels in two banks. Scans 15 channels per second. Size 9¼" x 4½" x 12½."

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USAK-K ¾" hole mount VHF/UHF ant. w/ 17' cable	$35.95
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Add $3.00 shipping for all *accessories* ordered at the same time.
Add $12.00 shipping per shortwave receiver.
Add $7.00 shipping per scanner and $3.00 per antenna.

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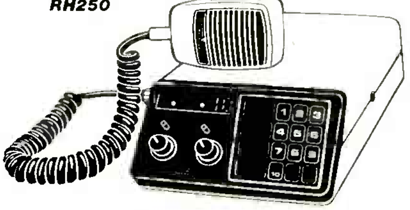

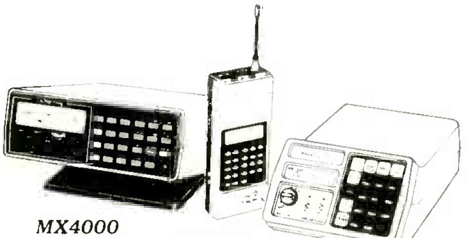

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CIRCLE 79 ON FREE INFORMATION CARD

WHAT'S NEWS

Phone-computer combination is a portable office

Comm 88, a Minneapolis manufacturer, has unveiled a complete portable office housed in a 6 × 13 × 18-inch briefcase. The case holds a Motorola cellular telephone, an Epson *Geneva* computer with flip-up 80-column screen, a Motorola *Datalink* cellular modem, an AC/DC rechargeable power system, and data communication, word processing, and electric spreadsheet software.

CELLULAR TELEPHONE, MODEM, computer and software make up a complete portable office, usable in a car or on the beach.

The *Portable Office* weighs 29 pounds and can be carried under any airplane seat. It is compatible with cellular telephone systems in more than 30 US cities. The user can send and receive calls or transmit data from taxicabs, boats, or even the golf course.

A built-in power system recharges in two hours from either AC or DC, and can even charge when the equipment is in use. Options include an external ring-alert for noisy areas, high-gain antennas, and dual batteries for up to 16 hours between charges. Suggested list price is $4,400.

Spaceborne lasers may measure wind, humidity

Researchers at RCA Astro-Electronics (East Windsor, NJ) report that they are developing spaceborne equipment to measure wind, temperature, and humidity in the Earth's atmosphere. The system uses lasers to make the measurements, reports Fred Shashoua, manager of the project. The first flights of the system may be as early as 1989, he believes.

The lidar (*LI*ght *D*etection *A*nd *R*anging) device uses a laser to measure wind. Directed at an angle to the approaching wind, reflection from the small particles always found in the atmosphere gives the wind speed in the same way that radar measures the speed of larger approaching objects.

Measuring temperature and humidity is more complicated, states Mr. Shashoua. Two lasers are required—one to act as a reference. To measure humidity, one laser is beamed at the area being checked. The wavelength of the light from that laser is that at which absorption varies most with changes in humidity. The other laser radiates at a frequency not greatly affected by changes in humidity.

The difference in the absorption of the two laser light beams is compared and used to determine humidity.

For temperature, the laser is set at a frequency at which the absorption by oxygen is greatest (a point in the infrared not far from the boundary of visible light). Oxygen's absorption varies rapidly with temperature, so comparing the absorption of the light from that laser with that of a laser set at a frequency at which little oxygen absorption takes place, yields an indication of the temperature.

Information from the system is expected to be valuable in helping aircraft avoid undesirable headwinds, and to the military, because heat-seeking and optically-guided missiles are hindered by fog. It can also reduce aircraft fuel consumption and enhance weather forecasting.

Software package simulates automatic factory layouts

Scientists of the General Electric Co. demonstrated to the 14th International Programmable Controllers Conference a software package that will enable manufacturing engineers to try out automated factories before they are built. The new software creates realistic representations of factories or parts of factories—complete with icons that resemble robots, forklift trucks, etc.—on the computer's video monitor. Techniques like those used in videogames bring the simulated factory to life: Work cells change color to indicate whether they are machining a part, waiting for material, or idled for maintenance or repair. Forklift trucks and automatic guided vehicles transfer parts from one machine to the next. Queues of parts build up in front of some machines, while others are waiting for parts.

With this installation in place and fed sufficient information, it is possible—by simply watching the simulated factory—to observe bot-

continued on page 6

ASSOCIATED RESEARCH, INC. B+K PRECISION FLUKE

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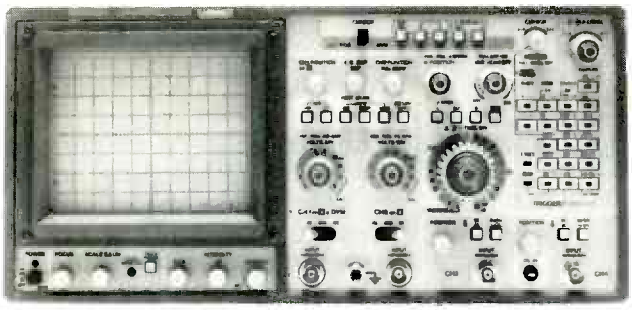
HITACHI Hitachi Denshi, Ltd. V1100A DC to 100 MHz Portable Readout Oscilloscope

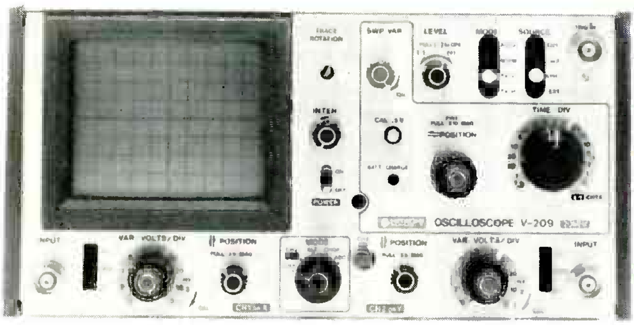


FEATURES

- Character display of set-up information on CRT (VOLTS/DIV, TIME/DIV, CAL or UNCAL, Delay Time, Trigger source, etc.)
- Cursor read-out function eliminates conventional calculation procedures (V, △V, △V%, △T, 1/△T, △T%, phase).
- Digital measuring function displays, DC voltage, AC voltage, and Frequency.
- Comment display function allows user's comments to be displayed on the CRT such as date and measurement data. Excellent for photo documentation.
- 4 channel, 8 trace, DC to 100 MHz, High sensitivity 1 mV/Div, Delayed sweep, Full TV triggering, Alternate triggering.

List Price $2,490.00 **Sale Price $2,250.00**

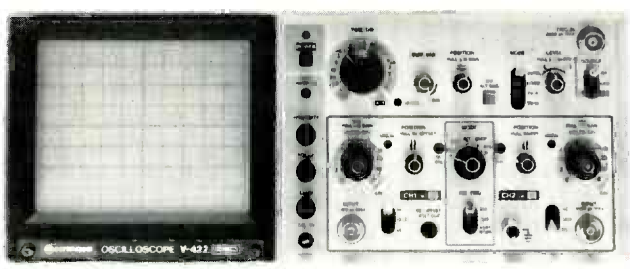
HITACHI Hitachi Denshi, Ltd. V-209 DC to 20 MHz Mini-Portable Dual-Trace Oscilloscope



- A three-way power supply takes the V-209 anywhere, anytime for speedy field measurements.
- High sensitivity (1 mV/div at 10MHz) and fast sweep times (50ns/-div) make the V-209 a valuable tool in R&D as well as servicing in a wide variety of applications including computers and video equipment.
- A Built-in TV sync separation circuit with easily selectable TV-V and TV-H modes ensures stable observation of both vertical and horizontal TV signal waveforms.
- An auto focus feature maintains constant trace without the necessity of troublesome manual focus adjustments.
- The V-209 is just what it claims to be—a powerful field service tool in a compact, lightweight package.

List Price $945.00 **Sale Price $708.00**

HITACHI Hitachi Denshi, Ltd. Portable Oscilloscopes



Model V-422 shown

CIRCLE 287 ON FREE INFORMATION CARD

MODEL V-212 **$461.00**

DC to 20 MHz, 1 mV/div, Dual Trace. Features 6" Rectangular CRT (w/two X10 probes).

MODEL V-422 **$694.00**

DC to 40 MHz, 1 mV/div, Dual Trace, D.C. offset for DMM Output, Verticle Mode Trigger 6" CRT (w/two X10 probes).

MODEL V-1050F **$1,276.00**

DC to 100 MHz, .5 mV/div, Quad Trace, Delayed Sweep. Full TV Triggering, Alternate time base (w/two X10 probes).

Full 2 year parts and labor warranties on the above scopes.

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IWATSU KEITHLEY LEADER Instruments Corporation Polaroid POWER DESIGNS Simpson

WHAT'S NEWS

tlenecks or other impediments to efficient production, and re-design to prevent them—add machine tools to help those that are overworked, install robots where needed, or to change layouts to bring the proposed facility to peak efficiency.

Telephone subdivision announced by EIA

The Consumer Electronics Group (CEG) of the Electronic Industries Association (EIA) has formed a Telephone Subdivision. The purpose, according to Tom Friel, President of the CEG, is to "enable us to be more responsive to the needs of this fast-growing segment of the consumer electronics industry."

Under an agreement between EIA's Consumer Electronics Group and the Information and Telecommunication Group (ITG), and approved by the EIA Board of Governors, CEG will coordinate state legislature activity, conduct consumer-affairs programs, gather and disseminate sales data on the retail telephone market, and continue the International Winter and Summer Consumer Electronics Shows (CES). ITG will be responsible for engineering standards, relations with the FCC, liaison with the Underwriters Laboratories, and marketing services related to the EIA statistical program covering telephones.

A Telephone Coordinating Committee consisting of companies from both CEG and ITG has been established. Membership on that committee entitles a company to full participation and voting rights in the telephone subdivisions of either group. That coordination is expected to eliminate duplication and permit EIA members to take full advantage of both groups' resources.

Newest programmable ROM has 15-ns access time

A new programmable read-only memory (PROM), with a 15-nanosecond access time—the fastest in the industry—has been developed by National Semiconductor of Santa Clara, CA. The new PL87X288B is a programmable logic device with five inputs, eight outputs, a fixed AND array generating all 32 product terms, and a programmable OR array. Typical power dissipation is 550 milliwatts. It operates over the commercial temperature range—0 to 70 degrees C. (A 20-ns military temperature range device is also available.)

Pricing in 100-up quantities is $2.20 each in plastic DIP and $3.10 each in ceramic.

New 3-D laser tracking system will measure robot arm motion

A new study at the National Bureau of Standards aims to improve greatly the measurement of performance of a variety of industrial robots.

Robots are being used more and more in manufacturing operations, but there is no agreement as to how their performance should be measured. Most manufacturers quote figures for the "accuracy" and "repeatability" of their robot arms, but these are "quasi-static" figures. But in many operations, kinematic measures of accuracy and repeatability, that trace the robot arm's motion as it moves in a continuous path at a rapid rate, are necessary.

The prototype, developed by the NBS, consists of a single laser interferometer, a servo-controlled tracking mirror, a similar target mirror mounted on the robot's wrist, and a computer to control the system. It makes continuous measurements of the position of the target mirror while the robot is moving at its normal working pace. The measurements include not only the three spatial dimensions, but also the pitch and roll of the robot's wrist.

In the finished device, precision transducers will measure the angular rotation of the mirrors and a standard interferometer will measure the path length of the beam. Such a device, NBS researchers say, would be able to measure the position of an industrial robot arm to an accuracy of 12 micrometers (0.0005 inch) over a 3-meter (9.8 foot) cube, an accuracy of about one part in 100,000.

Videotape vending machine accepts credit cards

A vending machine that rents or sells pre-recorded video cassettes on the insertion of a credit card has been introduced by Credit Vending, Inc., of Phoenix, AZ.

To rent a cassette, the customer simply places the credit card in the machine and enters the tape's number on a calculator-type keyboard. The card is verified electronically, the tape dispensed, and a receipt is issued. When the tape is returned, another receipt is issued. If a customer fails to return a tape, the credit card is charged for the price of the cassette.

At present, the machine accepts Visa or MasterCard, and rents VHS and Betamax format tapes.

The machine, the *Creditron Video Center,* is computer-controlled and modularly constructed. Tapes can have variable rental prices based on titles or day of the week rented. **R-E**

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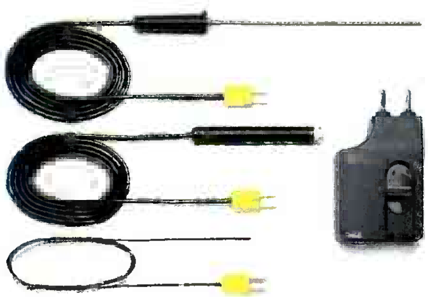

Surface, immersion and general-purpose probes with "mini" thermocouple connectors are available for the Fluke 80TK.

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Battery Life: 1600 Hours (9V)

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There's no stopping the incredible boom in consumer electronics. Soaring sales, new and improved products, entirely new technologies have opened up new opportunities for the trained technician as never before.

The $25 billion consumer electronics industry is creating a whole new servicing and repair market at home. This year, TV sales alone are expected to hit 16.2 *million* units. That's $5.5 billion dollars. Every day, sales of home VCRs, a product barely conceived of ten years ago, reach 20,000 units. Every day!

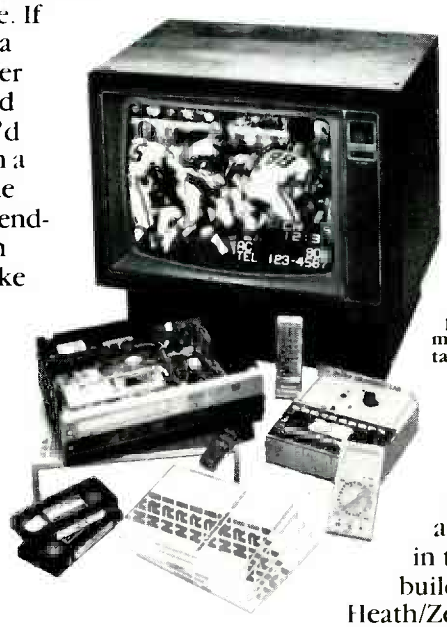
And the revolution has spread to the business sector as tens of thousands of companies are purchasing expensive high-tech video equipment used to train their employees and store important company data.

The High-Tech Revolution Is Just Starting

Already, disc players can handle both audio CDs as well as laser video discs. And coming are machines that will accommodate laser computer discs. Camcorders are becoming smaller, lighter and more versatile, 8mm video cassettes will produce high resolution pictures. Soon, our TVs will become interactive computer terminals, giving us entertainment, information and communications in one sophisticated unit.

Join the Future or Be Left Behind

Can you see the opportunity? The servicing and repair market that's there already . . . the enormous need created by the millions upon millions of electronic devices yet to come. If you're looking for a high-potential career in a clean, respected industry . . . if you'd like to get started in a field that's still wide open for the independent business person . . . even if you'd like to find a way to make extra money "moonlighting," now's the time to look into NRI at-home training.



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VIDEO NEWS

DAVID LACHENBRUCH
CONTRIBUTING EDITOR

• **Tubeless TV.** TV sets using LCD's instead of picture tubes are proliferating, and prices are coming down, although larger screen sizes are still not available. At the Summer Consumer Electronics Show in Chicago, four brands, with a total of 13 models, were shown; and manufacturers are promising plenty more to come. Among the biggest promises was Casio's pledge to introduce a 12-inch color picture-on-the-wall LCD TV early next year.

For the here and now, Casio chopped the price of its 2-inch black-and-white model with earphone sound to $100, and added a version with FM and AM at $130. Its 2.6-inch color model, with built-in loudspeaker and blacklight at $300 has audio and video jacks to permit use as a field video monitor; a color set with FM-AM is $350. Epson has two 2-inch color models at $350 and $399, and a tiny, black-and-white set, just the size of an audio cassette case at $199. Epson's sister brand, Seiko, (see photo) showed a 2-inch color set with built-in alarm clock and flip-up screen, while Citizen has 2.7-inch models—color at $299, and black-and-white with AM radio at $100.

• **A Good Buy.** With competition among domestic TV manufacturers and increased imports from Korea and Taiwan, the prices of color TV's actually are going down while everything else is going up. An RCA study indicates that the average retail price of a color set in 1967 was $568, while in 1984 it was $524. Since 1967, the government's Consumer Price Index has increased by 211 percent. RCA uses the government's figures to estimate that if color-TV sets had followed the inflationary trend of other consumer products, the average color set in 1984 would have cost $1,630!

• **Digital VCR's join TV's.** The company that originated digital TV sets is now working on VCR's. ITT Semiconductors is developing two basic IC's that replace hundreds of components and sharply improve the picture in home VCR's. The video recording itself is analog, and the components are said to be adaptable to any VCR system. ITT claims the IC's will make low-cost multi-standard (PAL, SECAM, and NTSC) VCR's possible, and eventually VCR's with built-in standards converters, able to record in any of the world's color TV standards, and play back in any other. ITT is aiming at a cost of $20 for the IC set, and availability in 1986.

ITT also says it now has a set of two IC's that provide multichannel TV sound, and that they will have a full-field memory IC next year that will allow TV sets with such features as freeze-frame, zoom, and interlace-free pictures that double the line rate of the incoming TV signal, providing 1,050 lines from a 525-line picture. ITT claims the same IC will also make possible an economical "multiple picture-in-picture" system, able to display nine different pictures on the same screen giving the viewer a sample of what's showing on all channels at the same time.

• **VHS Responds.** The VHS manufacturers are responding to Sony's new emphasis on 8mm by pushing hard on the virtues of the VHS format. Matsushita (Panasonic) and Hitachi have both developed camcorders taking full-sized VHS cassettes. JVC, the inventor of VHS, is pushing its *Video Movie*, using the small 20-minute VHS-C cassette that can be played back in a standard VHS deck by placing it in an adapter. JVC's top officials concede that while they are working toward a *Video Movie* machine with longer recording time, their top priority now is developing a new version considerably smaller than the existing model and with a better quality picture. **R-E**

NEW LIT

Transistor data book

The *Super E-Line Transistor Technical Handbook* is Ferranti Semiconductor's 112-page guide to its *Super E-Line* transistors, which offer one-watt power dissipation in TO-92 packages. The *Handbook* contains five sections: a detailed description of the *Super E-Line* chip and packaging technology, a product index listing commercial and quality-assured products, a selector table showing device types by application group, a technical data section with full specifications for each device in the series, and application notes showing the use of E-line transistors in typical circuits. Copies of the handbook can be obtained by contacting **Ferranti Electric, Semiconductor Div.,** 87 Modular Ave., Commack, NY 11725.

Transistor Selection Guide.

Ferranti's 6-page *MOSFET Selection Guide and Cross Reference List* offers design data on complementary N- and P-channel transistors. Arranged as an easy-to-read chart, it provides data on key parameters of over 150 MOSFET-devices in TO-92, TO-39, TO-220, and TO-3 packages.

Included in the guide are low-voltage threshold devices for telecommunications, superfast (1-ns) switching devices, and high-voltage, low-leakage devices for use in test instruments. It also contains key parameters of the various devices covered, among those specifications are: continuous current, I_D; breakdown voltage, BV_{DSS}, and on-resistance, $R_{DS(on)}$.

The guide also includes a cross-reference to help the user in selecting equivalent or near-equivalent devices.—**Ferranti Semiconductors**, 87 Modular Ave., Commack, NY 11725 R-E

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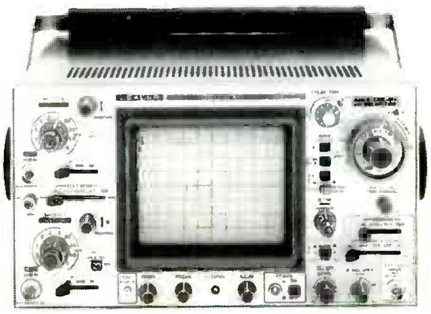

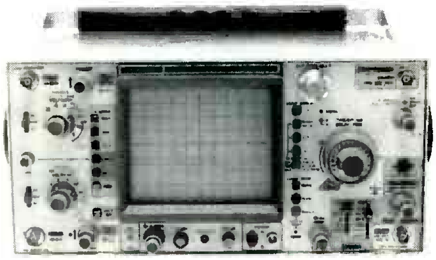

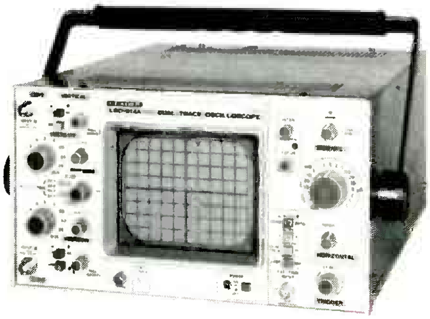

LBO 524L DC to 40 MHz

The LBO-524L is designed to meet a broad range of applications in design, testing and servicing of both analog and digital circuits and equipment. Its large 8x10 cm PDA CRT provides sharp, bright displays even at highest sweep rates. Comprehensive triggering controls including holdoff, alternate triggering and delayed sweep triggered functions permit stable displays for even the most complex signals. With 0.5 millivolt sensitivity, extremely low-level signals can easily be observed. A channel 1 output is available on the rear panel to drive other less sensitive instruments such as a frequency counter with an input level as low as 500 microvolts. The dual time base permits accurate observation and time interval measurements of complex waveforms.

$749.00

LBO-516 DC to 100 MHz

The LBO-516 is an economical 100-MHz, 3-channel, alternate time base oscilloscope. It has all of the important features that are expected in a 100-MHz oscilloscope such as full front panel operation, alternate triggering for simultaneous view of asynchronous signals and independent or simultaneous display of main and delayed time bases. The bright 20-kV PDA CRT and 0.5mV sensitivity permit sharp, bright displays of even those normally tough to see critical signals.

Eight trace capability is possible by displaying main and delayed versions of CH-1, CH-2, CH-3, and CH-1+CH-2. Also included are comprehensive triggering facilities with video sync separators, variable trigger holdoff, excellent trigger sensitivity and more.

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LBO-514A DC to 15 MHz

The LBO-514A is a compact 5-inch oscilloscope that offers maximum performance at low cost. Equipped with both vertical and horizontal magnifiers, it has 1-mV sensitivity with X5 magnification and a maximum sweep speed of 0.1 us/cm (0.2 s/cm to 0.5 usec in 18 calibrated steps plus X5 magnification). The LBO-514A provides both chop and alternate dual trace displays.

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÷1000 transformer. Features large jaw opening for industrial use.
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80TK SPECIFICATIONS
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−50 to 1000°C
−58 to 1832°F
Battery Life: 1600 Hours (9V)

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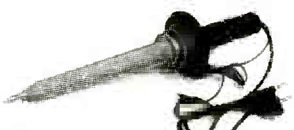

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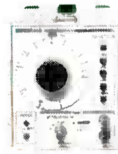

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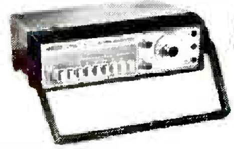

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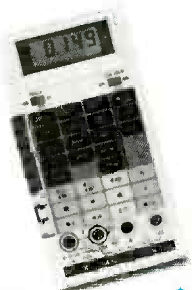

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DISCRETE COMPONENTS LIVE!

I would like to congratulate you for the article "High Power FET Audio Amp", in the December 1984 issue. It is the first complex, all discrete project in your magazine (or any other electronics magazine) in quite a long time!

I'd almost forgotten how mind-stretching an exercise it is to analyze a circuit, component by component. In this world of LSI and VLSI circuits, it is refreshing to see that, for certain applications, discrete components are not completely useless.

RODOLFO GARZAS.
Linares, N.L., Mexico

AUTOMOTIVE ELECTRONICS

I'm writing in response to your invitation to readers to express our preferences regarding articles about "non-repairable" modules. Particularly where automobiles are concerned, I would be very eager to see as much material as possible explaining the operation of electronically controlled engine systems. It seems to me that many of those who are involved in electronics in one way or another are also car nuts to some degree. As such, I predict that such an article, or preferably a series of articles, would be quite successful.

I attended a seminar for engineering students conducted by a GM engineer, and received the distinct impression that GM considers their system to be absolutely proprietary. The engineer refused to answer any questions that could be regarded as technical in any detail. It was as if he were trying to sell cars to his audience instead of presenting a seminar. I have read the engineering press, as well as the automotive press, and have never seen those systems discussed except in the broadest terms.

By the way, I am one of many who are ex-subscribers to *Popular Electronics*. Please don't change your basic format. I don't think your **ComputerDigest** adds much to the value of **Radio-Electronics**, but I congratulate you on keeping up your standards in the rest of the magazine. Keep up the good work and I'll keep recommending your magazine to students and associates.

JONATHAN SKEAN
Lincoln, NE

ADVERTISING RIP-OFF

In your January 1985 "Equipment Reports", you reviewed the TRS-80 *Model 4*. You mention the 64K RAM upgrade Radio Shack sells for that computer. After having it installed, however, I was informed that the upgrade can not be used to add memory to the machine, but only as a simulated disk drive. I was told that they think it can eventually be used as a memory add-on, but that they had not as yet figured out how. In light of that, I feel that Radio Shack's advertising is quite a rip-off.

HARRY L. DENMAN
Richland Hills, TX

MODULE REPAIR

I am a hobbyist in many areas of electronics: stereo, automotive electronics, TV, etc. I very much agree with Pete Kissa's letter ("Letters," **Radio-Electronics**, December 1984). I, too, would like to see more information concerning the troubleshooting and repair of electronics modules.

In your reply to Mr. Kissa's letter, you showed several examples of module replacement due to the failure of an inexpensive part. I know several years ago I had to buy a new electronic ignition module for my furnace. If the information and parts needed to do the repair were available, I am sure that the task would have required but a dollar of so of spare parts.

I agree that, at times, it may not be cost effective for a repair technician to troubleshoot and repair a module, etc. But certainly many times it is; and I believe that there are a very large number of people who would become more interested in the repair of such modules if the information needed to do so were available.

RICHARD V. WRIGHT
Sanford, NC

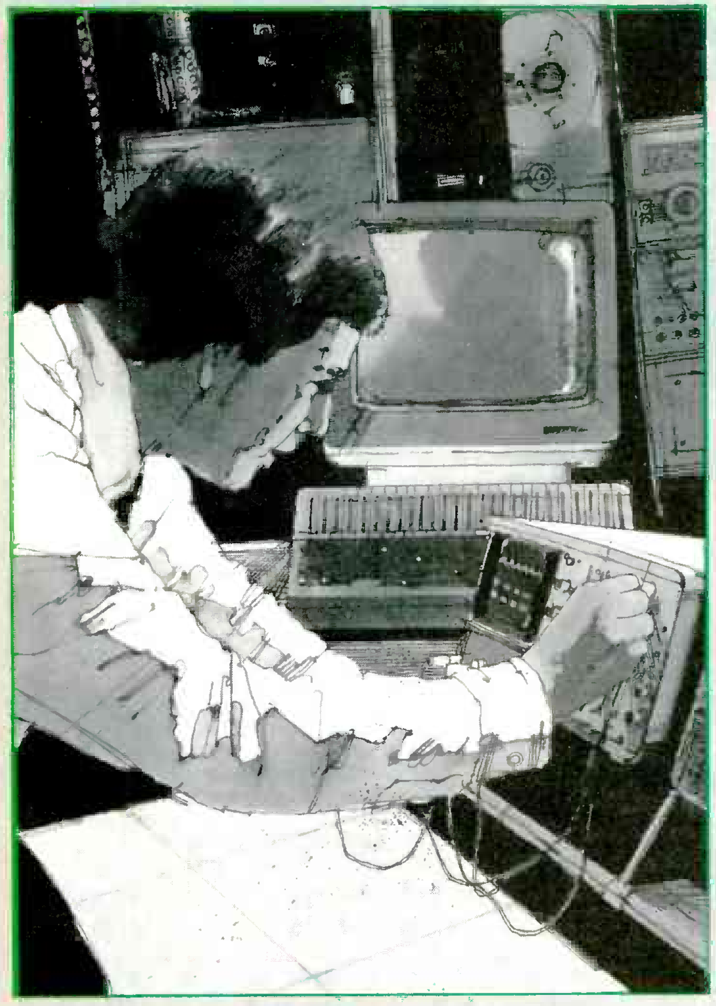
THE TESLA COIL

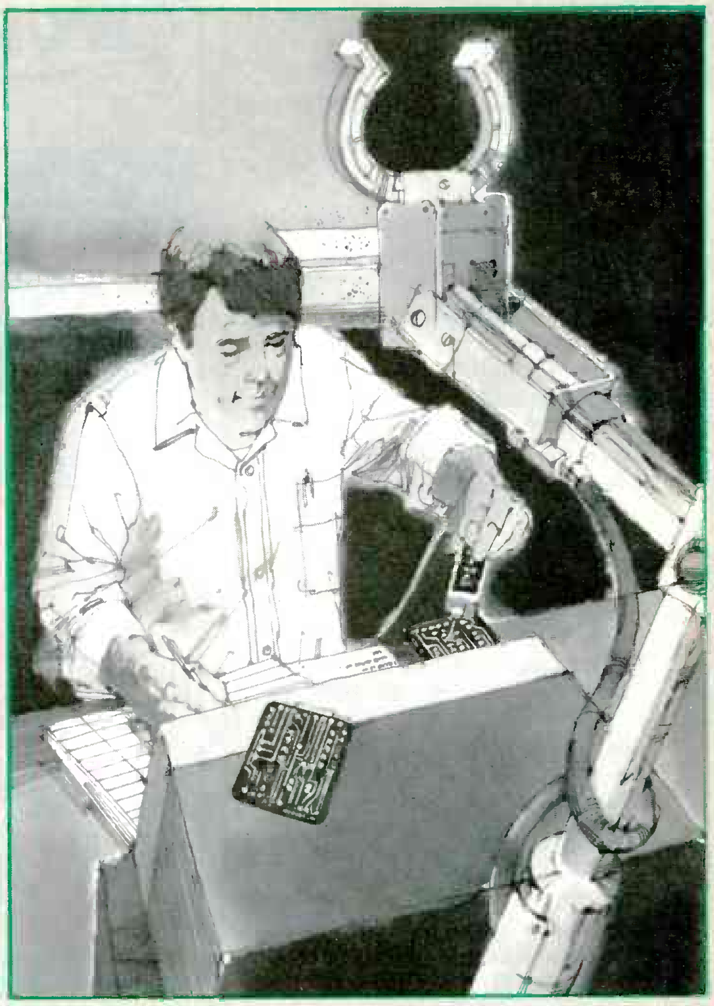
Robert Golka's account (**Radio-Electronics,** March 1985) of his recent investigations into ball lightning was fascinating. One statement regarding the "12.5-million volt Tesla coil" needs attention.

The June, 1900, *Century Magazine* carried an article on that coil. On page 176 there is an internal view of the laboratory, showing the coil actively producing discharges stated to represent 12-million volts. That figure has been used by researchers in establishing the maximum potential for the coil, and has been quoted time and time again.

The truth of the matter is that Tesla undertook hundreds of experiments with that coil, and with others, not all of which required a maximum output. Obviously, the 12-million-volt quotation could not have been the maximum capability, because some of Tesla's experiments produced discharges longer than the building itself. In such instances, the coil had to be tuned to produce its maximum potential at some point external to the building. Tesla stated that he had achieved an absolute potential of "18-million volts."

One of those experiments was described in a lecture before the New York section of the National Electric Light Association. Tesla showed a slide of his laboratory, in which his coil was apparently under full power. A description of the address was carried in the May 20, 1911, issue of the *Electrical Review and Western Electrician*. I quote:





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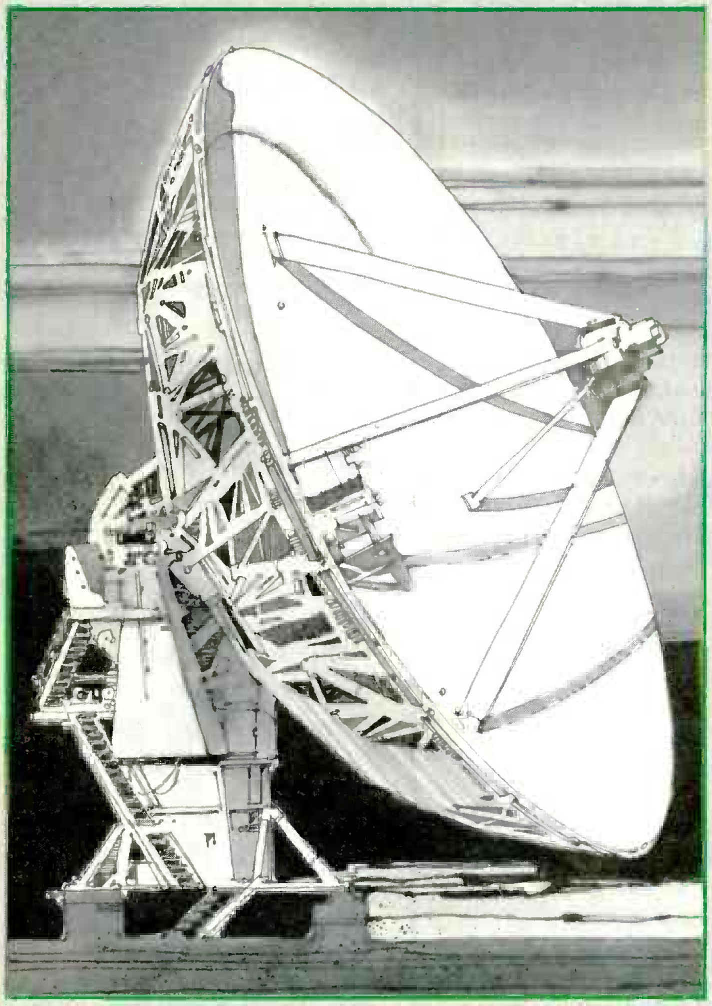

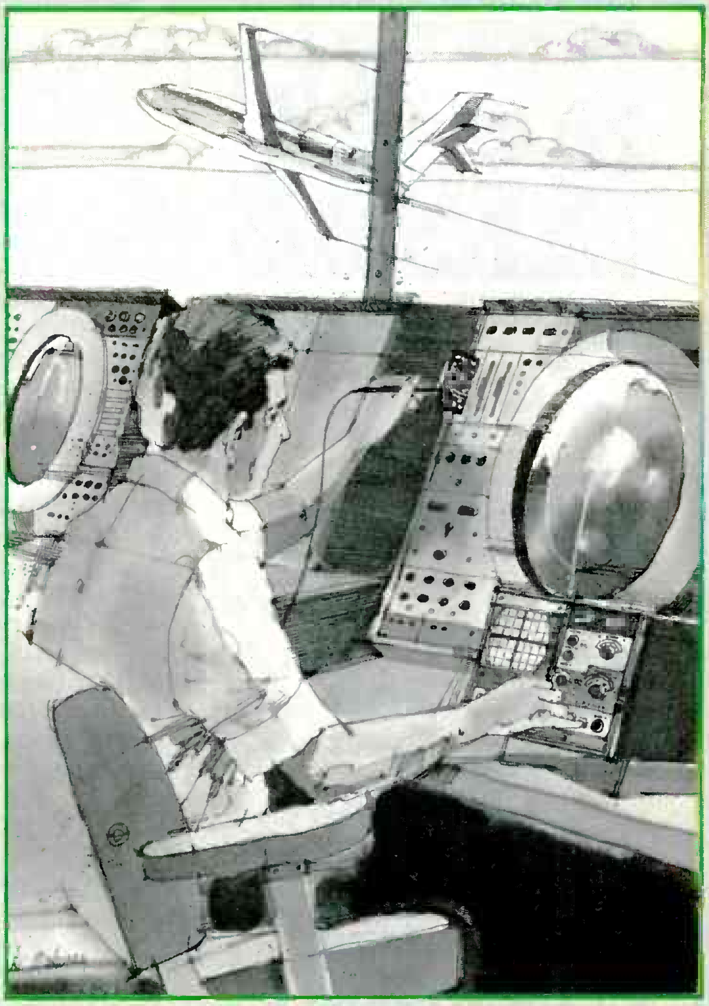

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Another instance in which researchers have erred is in regard to an article which appeared in Hugo Gernsback's *Electrical Experimenter* for June 1919. In discussing the capability of his machine, Tesla stated that "100,000,000 volts are perfectly practicable." Writers have picked that up and quoted it as an achievement, rather than a prediction (see **Radio-Electronics** for August, 1983). Tesla did design his Wardenclyffe broadcasting station for potentials of "30-million volts;" but, unfortunately, the project was never put into operation.

HARRY GOLDMAN,
Tesla Coil Builders' Association,
Glen Falls, NY

POWER METER

The article, "Power Meter for Your Stereo," by Mark S. Cohen, in the May 1985 **Radio-Electronics**, missed the mark as a speaker protector. First of all, the delay of four stages of sensing/amplification would allow plenty of time for a good healthy power surge to blitz any speaker. The slowest element is the relay.

Another major consideration is: What happens to the stereo amplifier? Very few power amplifiers are designed to handle a large power surge with no load. The designer should have connected a resistive load to the normally open circuits of the relay to protect the amplifier.

A third factor to consider is the relay's contact resistance and power-handling capacity. The parts list says only: "DPDT 12V DC relay." The higher the power of the stereo amplifier, the more critical are those factors. A high contact resistance can cause distortion and even power loss. But it does look like a darn good power meter.

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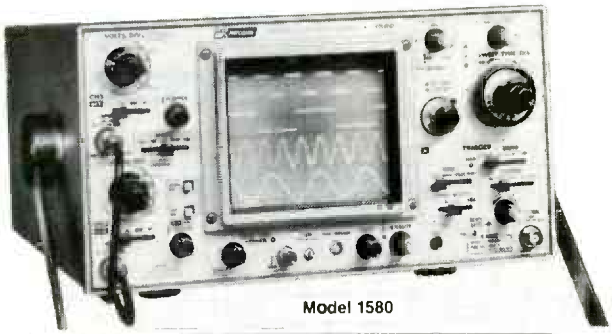

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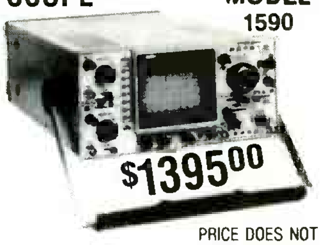

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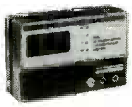

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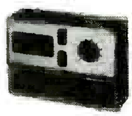

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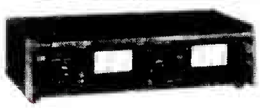

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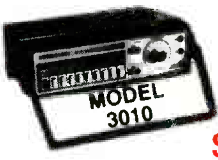

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Competition between home TVRO's and cable services

LAST MONTH WE EXAMINED THE REAL reasons HBO and other premium-program suppliers chose to scramble their satellite feeds. We came to the conclusion that, although unauthorized program viewing by home TVRO's was part of the problem, the real reason for scrambling was unauthorized distribution of program materials by local cable companies. We also pondered the likelihood that premium-program scrambling at 4 GHz might make it worthwhile for suppliers like HBO to serve private individuals.

There is one very emotional business conflict here. C-band premium programming was originally created for cable firms that affiliated themselves with premium-program suppliers. It was never intended for home TVRO's. Although a handful (numbering in the tens of thousands) of home TVRO's may have been a source of "amusement" to cable operators a few years ago, the home-TVRO industry of 1985 no longer amuses cable executives. Here's why:

- A recent national study showed that although 72.1% of all home-TVRO owners live where no cable TV service is available, 26.5% *do* have cable service available.
- Of the 26.5% who do have cable available, 48.7% of those are *former* cable subscribers.

That means that about 1 in 4 home-TVRO users could have cable if they wanted it, and that half of that number, or 1 in 8 overall, have discontinued cable in favor of TVRO. Those are rather sobering numbers. Suppose cable were to lose 1 subscriber in 8 nationwide to home-TVRO system ownership?

* Publisher, CSD magazine

FIG. 1

Cable and TVRO competition

Cable and home TVRO are, at the moment, competitors for consumers' entertainment dollars. From the perspective of the cable operator, the home-TVRO industry is feeding off the programming services created by cable, and paid for by cable. Because the majority of the most desirable satellite services are on satellite primarily to reach cable-service subscribers, it appears to the cable people that TVRO is getting a free ride at their expense. And if the present trend of TVRO sales continues into areas where cable is available, that 1-in-8 ratio may end up being 1-in-7 or 1-in-6 very soon. Cable doesn't like having to compete with itself!

A possible solution

If all the most desirable cable programming on C-band were simply scrambled, ownership of a C-band TVRO would quickly become much less desirable. There are well-researched studies to back up that contention. For example, the recently completed 1985 CSD "Home Marketing Study" surveyed more than 4,800 randomly selected owners of TVRO systems. The result was more than 150 charts, tables, and demographic profiles that provided the home-TVRO industry with its first insightful look into the complex TVRO marketplace. Here are a few of the findings:

- 66% of all home-TVRO owners watch movies as their primary form of satellite-originated entertainment.
- 54.4% of all home-TVRO owners view HBO at least once every 24 hours.
- 36.9% of all home-TVRO owners view WTBS (Super Station Atlanta) at least once very 24 hours.
- 28.9% of all home-TVRO owners view ESPN (the *E*astern *SP*orts *N*etwork channel) at least once every 24 hours.

Those statistics clearly show that movies are the primary source of viewing entertainment, and that sports and news are well down the list. Now suppose the top three (movies, sports, and news) were moved to 12 GHz?

Arguments for a 12 GHz (Ku-band) service have been around for a long time. For one, the dishes are smaller than comparable C-band units—typically 4 feet or less (see Fig. 1). In addition, the equipment cost, ultimately, would be lower ($500 per system when bought in volume). Further, interference with microwave links, which is a problem with C-band equipment, is eliminated. Most important, though, by moving home viewers to 12 GHz, the cable firms would feel less threatened, since 12-GHz feeds, from the beginning, would be designed solely for home viewers.

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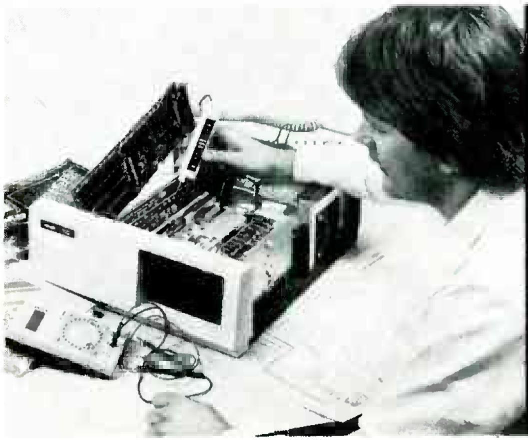

Field servicing is interesting and rewarding. Technicians may work for a service company, manufacturer, or major users.

The NTS/HEATH HS-151 PC completed, includes monitor and full-function keyboard with calculatc style keypad, and typewriter format.

such an approach, and wonders how to get the home-TVRO viewers away from 4 GHz and onto a band where their legitimate service needs can be handled without the conflict that currently exists between cable and home TVRO.

Until now, there has been little in the way of programming on 12-GHz (at least when compared with 4-GHz). That is something that will rapidly change. Here's why:

- RCA will launch, within 12 months, a pair of moderate power Ku-band satellites. An early customer is *Holiday Inn* who plans a four-channel service for its national motel chain.
- Ku-band receiving equipment originally developed for European and Japanese satellites needs a volume market, and at the moment neither Europe nor Japan seems to be capable of creating volume demand. The U.S. may be able to do so.
- Ku-band satellites are more flexible than C-band satellites. Ku-band transponders have nearly twice the bandwidth (typically 54 MHz). That allows using one full transponder for super-power or super-resolution services, or, by splitting a transponder, two unrelated TV channels may each use half of the transponder. That increases program packaging and scrambling options.

HBO first considered Ku-band program distribution back in 1983. More recently, Showtime, HBO's chief competitor, has been doing its own studies of just how a package of desirable cable services might be set up for home delivery via Ku-band satellites. It is all speculative now, but the handwriting is on the wall: Ku is coming, and one way or the other, it will play an important role in the home-TVRO systems of the late 1980's.

Technical problems

The addition of a Ku-band "head" to an existing C-band system presents several problems. Most of the newer home-TVRO receivers use block down-conversion, or BDC. (See "Know Before you Buy" in the June 1985 issue of **Radio-Electronics**.) BDC is tailor-made for dual-band reception—4 and 12 GHz, that is. The existing 4-GHz LNB (*L*ow *N*oise *B*lock down-converter), or anten-

continued on page 90

TVRO dealer "Starter Kit" available

Bob Cooper's *CSD Magazine* has arranged with a number of TVRO equipment suppliers to provide a single-package of material that will help introduce you to the world of TVRO dealership. A short booklet written by Bob Cooper describes the start-up pitfalls to be avoided by any would-be TVRO dealer, in addition, product data and pricing sheets from prominent suppliers in the field are included. That package of material is free of charge and is supplied to firms or individuals in the electronics service business as an introduction to the 1984/85 world of selling TVRO systems retail.

You may obtain your *TVRO Dealer Starter Kit* free of charge by writing on company letterhead, or by enclosing a business card with your request. Address your inquiries to: *TVRO STARTER KIT, P.O. Box 100858, Fort Lauderdale, FL 33310.* That kit *not* available to individuals not involved in some form of electronics sales and service.

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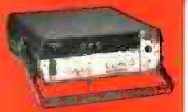

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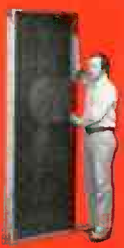

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The *7930* has a maximum power output of 25 watts. Features include priority scan, 21-memory storage, memory scanning, band scanning, time- or carrier-operated squelch in the scanning mode, and a choice of high or low power.

That last feature is especially important in helping to reduce band congestion. In some situations, such as when you are located near the repeater you are using, you may not need to operate your transceiver at full power. Well, Kenwood has made it so easy to reduce your output power that you simply have no excuse not to. With a flick of a switch the *7930*'s power level may be reduced from 25 to 5 watts.

The front panel of the *7930* has a

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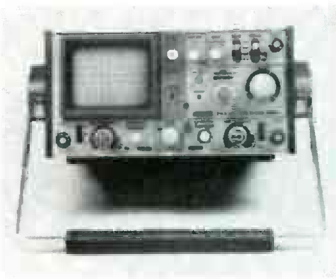
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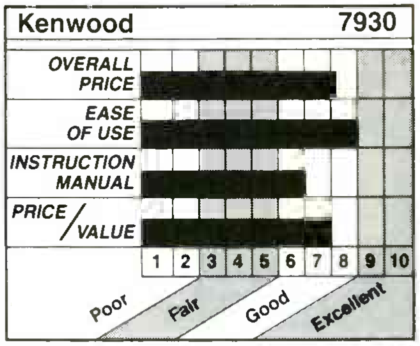

clean, uncluttered appearance. There is a 16-key DTMF pad, an ON/OFF switch, a squelch control, and a rocker switch that allows you to choose between using the 21-position rotary switch to select a frequency previously stored in the *7930*'s memory, and using the keypad to enter the desired frequency. In addition, there are six pushbuttons that allow you to:

- Reverse transmit and receive frequencies.
- Activate the tone for repeaters that use tone access.
- Select high or low power.
- Select carrier- or time-operated scanning. In carrier scanning, the *7930* scans through the frequencies you have previously stored in memory. As soon as it finds a channel with a carrier, it stops and allows you to hear what's going on. It remains on that channel until the carrier disappears, at which time it continues scanning. In time-operated scanning, the *7930* again stops on each channel it finds with a carrier, but remains there for only about five seconds before moving on.
- Select the alert function. The *7930* allows you to designate one channel as an alert channel. When scanning, the *7930* checks that channel every five seconds, and remains there when a carrier is present.
- Select priority mode. That switch gives you a quick way of forcing the *7930* to lock in your priority channel.

The *7930's* front panel is completed by a green LCD (*L*iquid *C*rystal *D*isplay) that gives a digital display of the currently selected frequency. In addition, the LCD shows whether a repeater's input is up or down, whether the transceiver is in reverse or priority modes, and whether the station

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you are listening to is on frequency. Completing the display is a red and yellow LED bargraph that indicates signal strength when receiving and power output when transmitting.

The *7930's* frequency coverage has been extended above and below the strict 144–148 MHz amateur band to cover the Military Affiliated Radio Service (MARS), located at 142–148.995 MHz. That means that the transceiver can also be used with the Civil Air Patrol, with which many amateurs are associated.

A compact unit, the *7930* measures 6⅞ × 2½ × 8¹⁄₁₆ inches, and weighs about four pounds. The microprocessor-controlled unit features frequency synthesized tuning. Note that though you might expect spurious signals generated by the microprocessor circuit to be a problem, no "birdies" were observed during our tests of the *7930*.

The *7930* has an impressive set of specifications. For example, its rated maximum output is 25 watts; that can be reduced to 5 watts via the front-panel switch previously mentioned. Modulation deviation is 5 kHz. Spurious output is rated at −70 db (−60 dB at the low-power setting). Stability of the frequency synthesized tuner is better than 15 ppm over a temperature range of −20°C to +50°C.

Turning to the receiver section, sensitivity is rated at 0.25 μV for 12 dB SINAD. Squelch threshold is specified as 0.6 μV or less. Spurious rejection is −70 dB. Selectivity is 12 kHz minimum at −6 dB and 24 kHz maximum at −60 db. The audio output is 2 watts into an 8-ohm load.

In the presence of high levels of external RF, the *7930* has one potential problem: front-end overload. The transceiver is as free from intermodulation distortion as any other on the market, but in the presence of high levels of RF, a common occurrence in many parts of the country, the receiver could be completely blanked out. Kenwood may want to consider adding more internal shielding to the unit, as well as sharper band-stop filtering, to help prevent that problem.

Our other main complaint with the transceiver is not with the transceiver itself; it's the lack of technical detail in the documentation. That is a far cry from the days when complete information always came with such transceivers, including detailed servicing information. Few rigs today, including the *7930*, come with such information. Instead, the manufacturer prefers that you box the unit up and return it to the factory for repair.

However, the material that is included in the the documentation does give a good explanation of how to set up the transceiver, and how to take advantage of its many fine features.

The Kenwood *7930* should provide you with years of good service, whether used as a base or mobile rig. The *7930* lists for $359.95; for more information, contact Kenwood Communications, 1111 West Walnut, Compton, CA 90220. **R-E**

continued on page 42

Vidicraft CCU-120 Commercial Cutter and Event Timer

CIRCLE 111 ON FREE INFORMATION CARD

Now you can automatically edit commercials out of your VCR recordings!

DID YOU EVER WISH THAT THERE WAS some way to edit commercials out of what you tape? Of course if you are watching what you tape, you can always manually stop and start your VCR. However, if you're watching something else, or if you're away and letting your timer do the work, then you get the commercials along with the program material. But not if you use the *CCU-120* commercial cutter and event timer from Vidicraft (0704 S.W. Bancroft St. Portland, Oregon 97201).

The *CCU-120* receives video and audio signals from your VCR and analyzes them so that it can identify commercials. When it spots what it thinks is a commercial, it does not stop your recorder. Instead, it waits until the commercial ends, rewinds the tape to where the beginning of the commercial and then resumes recording. That way, you don't lose any material if the commercial cutter decides that what it thought was a commercial turns out not to be.

Determining what is a commercial and what is programming material can be difficult, because the TV signal looks the same for each. To make its determination, the *CCU-120* looks for fades to black, audio fades, time between fades, scene changes, etc. Unfortunately, it is possible for the *CCU-120* to mistake commercials for program segments, and to mistake program segments for commercials. (Devising a commercial "detection" scheme that works 100% of the time is by far the most difficult part of designing an effective commercial cutter. To date, no manufacturer has come up with a foolproof scheme.)

For example, if you try to delete the commercials from a news broadcast, you might be disappointed by the results. That's because news programs are typically made up of many segments, some of which will be deleted because they look like commercials to the *CCU-120*. Other programs with scene changes that look like commercials would be affected similarly. But a built-in "safety" feature limits program loss in those cases to two minutes.

It's also possible that the *CCU-120* won't recognize a com-

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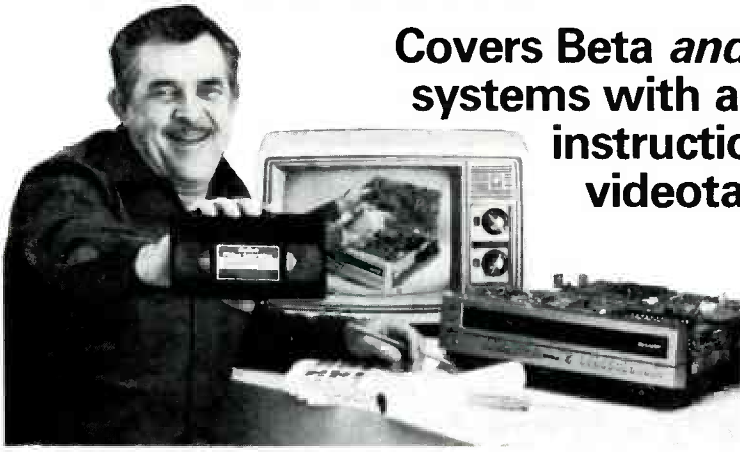

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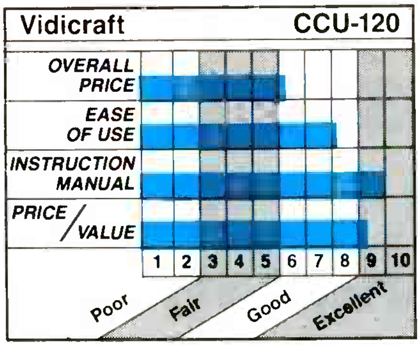
2600-105

mercial, depending on how the transition from program material is made. In general, the commercial cutter works well with network broadcasts, which are usually well produced. However, sloppy transitions, which occur from time to time in local broadcasts, will give the commercial cutter trouble.

As we mentioned previously, the *CCU-120* positively identifies a commercial only after it's completed. That helps to avoid cutting out large segments of program material. The disadvantage of that method is that while your VCR is rewinding the tape to where the commercial began, you can miss some program material. The length of rewind time can run from about 8 to 18 seconds, depending on the VCR used.

Controlling your VCR

The *CCU-120* uses an infrared emitter to control the VCR functions. The emitter is attached in front of your VCR's IR sensor using a self-adhesive Velcro fastener. Since different VCR's need to see



different kinds of signals from a remote controller, the *CCU-120* must be set up to work with that particular VCR. If your wireless remote can access the RECORD, BACKSCAN, PLAY, PAUSE, and STOP functions of your VCR, then it is likely that there is a version of the commercial cutter made for it. For example, the unit we had could be used with several VCR models from Sony, Panasonic, RCA, Magnavox, G-E, Hitachi, Canon, and Quasar.

Besides being a commercial cutter, the *CCU-120* is a 15-event, 9-week timer. The timer is easy to use, and is more versatile than most VCR timers. For example, it has daily, weekly, and *weekday* event options.

As you might have guessed, the commercial cutter is microprocessor controlled. Two Z80's are used; one runs the cutter routines, real-time clock, and handles the user interfaces, and the other takes care of the infrared interface with your VCR. The software for the two Z80's is held in four 2732 EPROM's. If you buy a new VCR model, Vidicraft can change the appropriate EPROM's for a small fee.

If you dislike commercials so much that you don't mind losing a bit of program material here and there, then the *CCU-120* is for you. Even if you don't want to cut commercials from everything you tape, you'll still like the CCU-120's timer—it's one of the best we've seen. You might even be tempted to buy a VCR with fewer timer features; the money you'd save would help take the bite out of the CCU-120's $470 list price. **R-E**

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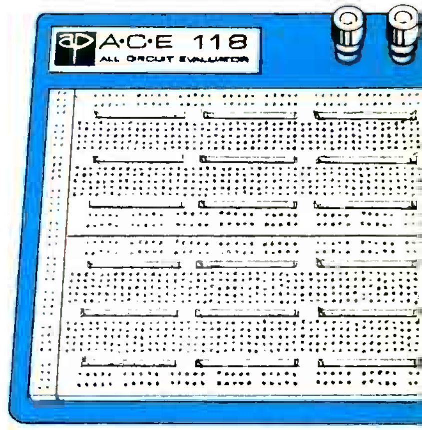

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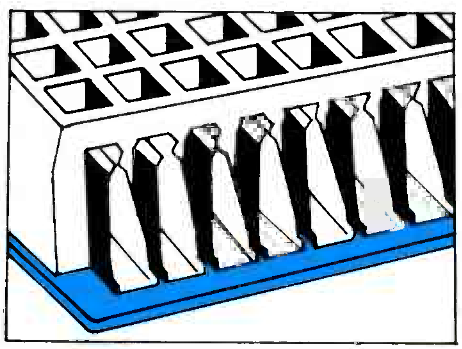
The ACE 109 has two terminals for separate voltages plus a ground connection. The larger ACE 118 offers the same three terminals, plus an additional terminal which can be used for clocking or another voltage. The backplates are heavy steel to keep the boards stationary.



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NEW IDEAS

A versatile, low-cost logic probe

THE LOW-COST LOGIC PROBE PRESENTED here is a must for anyone who experiments with digital circuits and whose budget can't tolerate a $35.00 logic probe in a fancy case. This circuit uses popular components, provides utility that rivals that of commercial units and, best of all, costs as little as $6.00 to build. The complete circuit is shown in Fig. 1-*a*.

How it works

Diode D1 is included for protection against reversed-polarity inputs. A logic-low input causes LED1 to light, and a logic-high input causes LED2 to light. The 555 acts as a pulse catcher; when PULSE switch S2 is open, LED3 lights up for about one second each time a pulse is detected. Resistor R4 and capacitor C2 determine the "on" time of LED3. To change that time, figure that for each 10 μF of capacitance, the LED will light for about 1 second. The table shown in Fig. 1-*b* gives "on" times for several values of C2. Just remember that you don't want LED3 to stay on too long, or you might miss pulses.

Construction is not critical. If you wish you can wire the circuit on a piece of perfboard using either point-to-point or wire-wrap techniques.

You may want to use different colored LED's for LED1, LED2, and LED3—say green, red, and yellow. The green LED will indicate a logic low, the red LED a logic high, and the yellow LED a pulse. If you don't have a 74L04 handy, you can use a 74L00 as an inverter by tying both inputs from one gate together, as shown in Fig. 1-*c*.

How to use it

Connect the +5-VOLT and GROUND terminals to the corresponding points in the circuit under test. Then attach the LOGIC INPUT terminal to the point you wish to monitor via a probe (such as a spare VOM probe) and close READ switch S1. Either LED1 or LED2 will light to indicate the state of that point. Switch S2, PULSE, should be open to use the pulse-catcher; closing it sends the 555 into a reset state, which forces the output low and turns off LED3.

The circuit was designed to work with TTL signals. It will probably work with CMOS, but it may load the circuit under test. Also, the 74L04 will only work with a 5-volt circuit. —*Stan Stepnowski III*

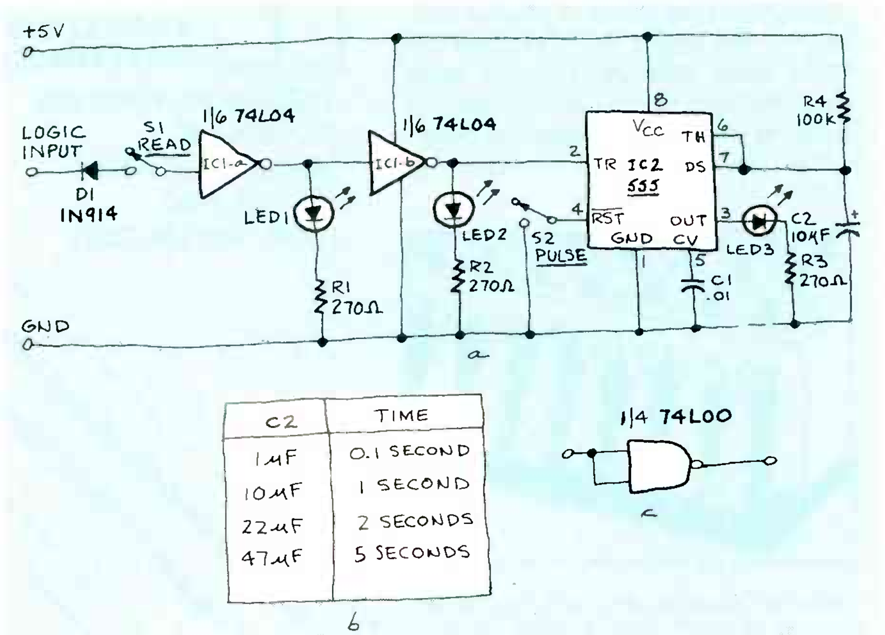

FIG. 1

NEW IDEAS

This column is devoted to new ideas, circuits, device applications, construction techniques, helpful hints, etc.

All published entries, upon publication, will earn $25. In addition, for U.S. residents only, Panavise will donate their *model 333*—The Rapid Assembly Circuit Board Holder, having a retail price of $39.95. It features an eight-position rotating adjustment, indexing at 45-degree increments, and six positive lock positions in the vertical plane, giving you a full ten-inch height adjustment for comfortable working.

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You'll find these features in a full line of Heavy Duty DMMs that offer a 4½ digit readout, 0.05% VDC accuracy, a 10-amp current range, a 2000-hour battery life, diode test, true RMS and temperature measurement. All this and a no-questions, one-year warranty.

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NEW PRODUCTS

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VIDEO SYSTEM, the *Canovision 8*, is a lightweight, three-piece 8mm home video system. The components include a three-pound, five-ounce model *VC-200A* color video camera; a four-pound, one-ounce model *VR-E10* four-head 8mm videotape recorder; and a model *VT-E10* four-program 14-day tuner/timer. The recorder and the camera can be used with other Canon video cameras and recorders.

The model *VC-200A* is a full-function video camera with an f/1.2 lens with 8.5–51mm (6X) two-speed power zoom control and macro feature for focusing as close as 3/16". The picture tube gives better than 270 lines horizontal resolution. Low-light performance is 20 lux, exposure is completely automatic, and there is a backlight control. The model *VC-200A* has a suggested price of $1,000.00.

The model *VR-E10* recorder can record up to 90 minutes with Canon P6-90 tape. When it is used with a battery, the recording time is either 85 or 45 minutes, depending on the battery type. Four video heads ensure flicker-free freeze-frame operation, and an FM audio system provide a high signal-to-noise ratio and 30–14,000Hz frequency response. The model *VR-E10* has a suggested price of $900.00.

The model *VT-E10* tuner/timer has a 105-channel potential, with pushbuttons for selecting any 14 channels. It can be programmed to record up to four different programs on the same or different channels over a 14-day period. The model *VT-E10* has a suggested price of $300.00.— **Canon USA, Inc.**, One Canon Plaza, Lake Success, NY 11042.

DOWNCONVERSION RECEIVERS, model *UST 5000*, model *UST 6000*, and model *UST 7000* (shown), use advanced block-downconversion technology to provide more stable satellite-TV picture reception and to allow several users, under one roof, to access various TV programs independently from one common dish.

The model *UST 5000* incorporates a touch-control front panel with LED channel display, adjustable audio, channel up and down, fine-tuning skew adjustment, polarity control, and vertical and horizontal polarity indicators. The unit's slow-and-fast scan features allow users to peruse the variety of programming available when mov-

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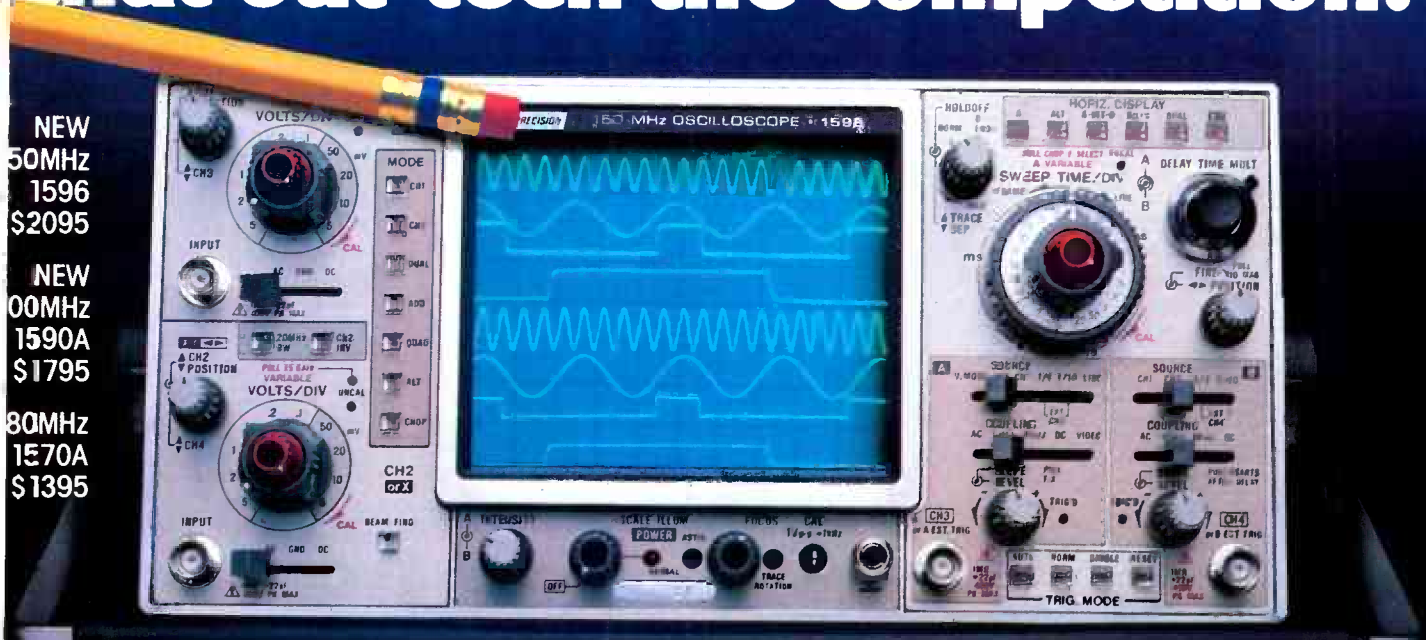

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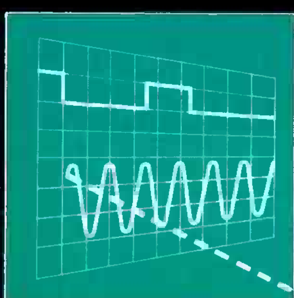

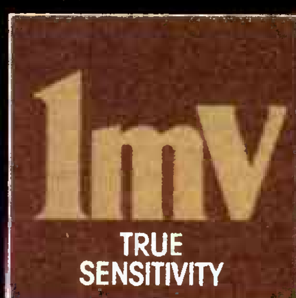

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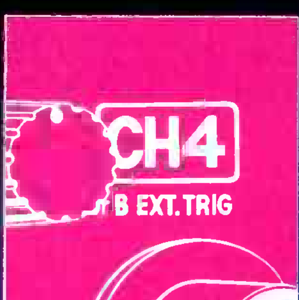

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ing from one channel to another or one satellite to another. It is priced at $349.00.

The model *UST 6000* adds several features to the model *UST 5000*. An Infrared handheld remote control offers users the convenience of moving from one channel to another at the touch of a button. Polarity and power controls are also included in the handheld unit. The receiver is highlighted by expanded audio controls, and the *VST 6000* can handle stereo (matrix and discrete formats) as well as mono. The *UST 6000* is priced at $599.00.

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The model *UST 7000* adds more features to the model *UST 6000*. The handheld infrared remote unit has a built-in programmable dish control that accommodates up to 81 different satellite positions. The programming controls include pre-programmed polarity. The unit is also equipped with expanded audio capabilities that include both narrow and wide audio formats and Dynamic Noise Reduction (DNR). Two LED displays provide readouts, that indicate which audio frequency is currently being received. Also included is an LED satellite position and clock indicator, along with an LED level indicator that illustrates (by the number of lights illuminated) the strength of the incoming satellite signal. The *UST 7000* is priced at $999.00.—**Uniden,** 15161 Triton Lane, Huntington Beach, CA 92649.

OSCILLOSCOPE, model *9060*, features three DC to 60 MHz vertical amplifiers. Up to 1 mV/division sensitivity at 20-MHz bandwidth may be obtained with the ×5 magnifier switch on. The horizontal time base ranges from 0.5 sec./div. to 50 ns/div., and there is an ×10 magnifier switch to extend the range to 5 ns/div. A six-inch rectangular CRT provides brighter traces, and an internal illuminated

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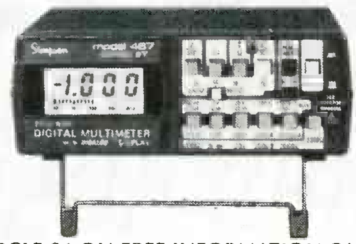
graticule that provides an easily-read, parallax-free display.

The model *9060* is priced at $1,195.00.—**Beckman Industrial Corporation,** 630 Puente Street, Brea, CA 92621.

DIGITAL MULTIMETER, model *467-2T*, is specifically designed for telecommunications servicing. It is a 3½-digit instrument with direct-reading dB ranges. It also has a built-in 1004 Hz tone generator for line checking and signal tracing.

The model *467-2T* has Simpson's Digalog™ (digital and analog) LCD readout with pulse, continuity, and low-battery indicators. The DMM has true RMS AC capability. 29 ranges are optimized for telecommunications testing: 200 mV to 1000 volts DC (5 ranges), 200 mV to 750 volts AC (5 ranges), −60 to +20 dB (3 ranges), 200 ohms to 20



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megohms (6 ranges, 3 low power), 200 μA to 2000 mA AC current (5 ranges), 200 μA to 2000 mA DC current (5 ranges).

Other functions include audible/visual continuity indications, logic-level detection up to 35 volts, diode test, and differential peak hold. A single 9-volt battery provides up to 100 hours of continuous operation. The model *467-2T* is priced at $350.00.—**Simpson Electric Company,** 853 Dundee Ave., Elgin, IL 60120. **R-E**

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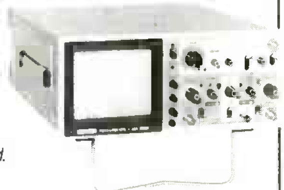

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Probes included.

• Thin, lightweight, compact • Large 6″ rectangular, internal graticule CRT • Autofocus

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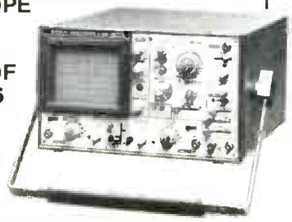

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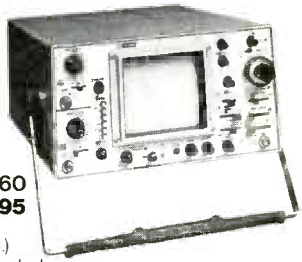

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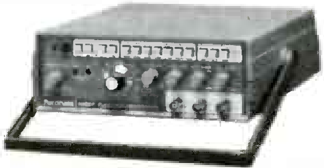

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Versatile Bench Power Supply

VAUGHN D. MARTIN

No electronics workbench is complete without a variable power supply. If you're still missing that essential tool, here's a versatile six-output supply you'll want to build.

A VARIABLE POWER SUPPLY IS AN ESSENTIAL part of any electronics workbench. If your workbench is lacking one, then this supply is for you! It's inexpensive, easy-to-build, and it's more than just a power supply: It includes two variable, precision voltage-reference outputs too!

The power supply provides three pairs of complementary voltage sources. Each output has built-in current limiting, and all share a common ground. While the supply is designed for low- to medium-current applications, we'll show you how to increase the current capability of the non-precision sources to 2 amps.

The first pair of voltage sources, $+V_S$ and $-V_S$, are independently adjustable. Each has a 15-volt range of adjustment and can supply a current of 100 ma.

The second pair, $+V_T$ and $-V_T$, is dual-tracking: The outputs, which are adjusted using a single control, are equal in magnitude and opposite in polarity. The adjustment range of the dual-tracking outputs is the same as for the independent supplies. The tracking sources can also supply 100 ma of current.

The third pair of outputs, $+V_P$ and $-V_P$, is a set of precision voltage sources, one positive and one negative with respect to ground. The output of each is set by a 10-turn potentiometer and turns-counting dial. Those supplies have a somewhat wider voltage range (25 volts each), but have very low current output (4 mA). They are intended, once calibrated, to be used as secondary calibration standards, not to supply operating current to working circuitry.

One of the special features of this power supply is that each pair of outputs is completely independent of the others, so you need only build the output pairs that you need. For example, if you don't need the precision source, simply omit all components associated with it. (Even if you omit one section, we recommend using the printed-circuit artwork provided; it will make it easy to add the section later.)

Circuit operation

As you can see from Fig. 1, the power supply is made up of four main sections: The rectifier circuit is shown at the upper left of the diagram, the precision sources at the upper right, the dual-tracking supply at the lower left, and the independent supplies at the lower right.

The rectifier circuit

The rectifier circuit supplies half-wave rectified DC to each section of the power supply. Note that the polarity of the diodes and capacitors for the positive supplies is opposite that of those for the negative supplies. The non-precision supplies are powered by the ±20-volt rectifier outputs, while the precision sources get their raw power from the ±40-volt rectifier outputs.

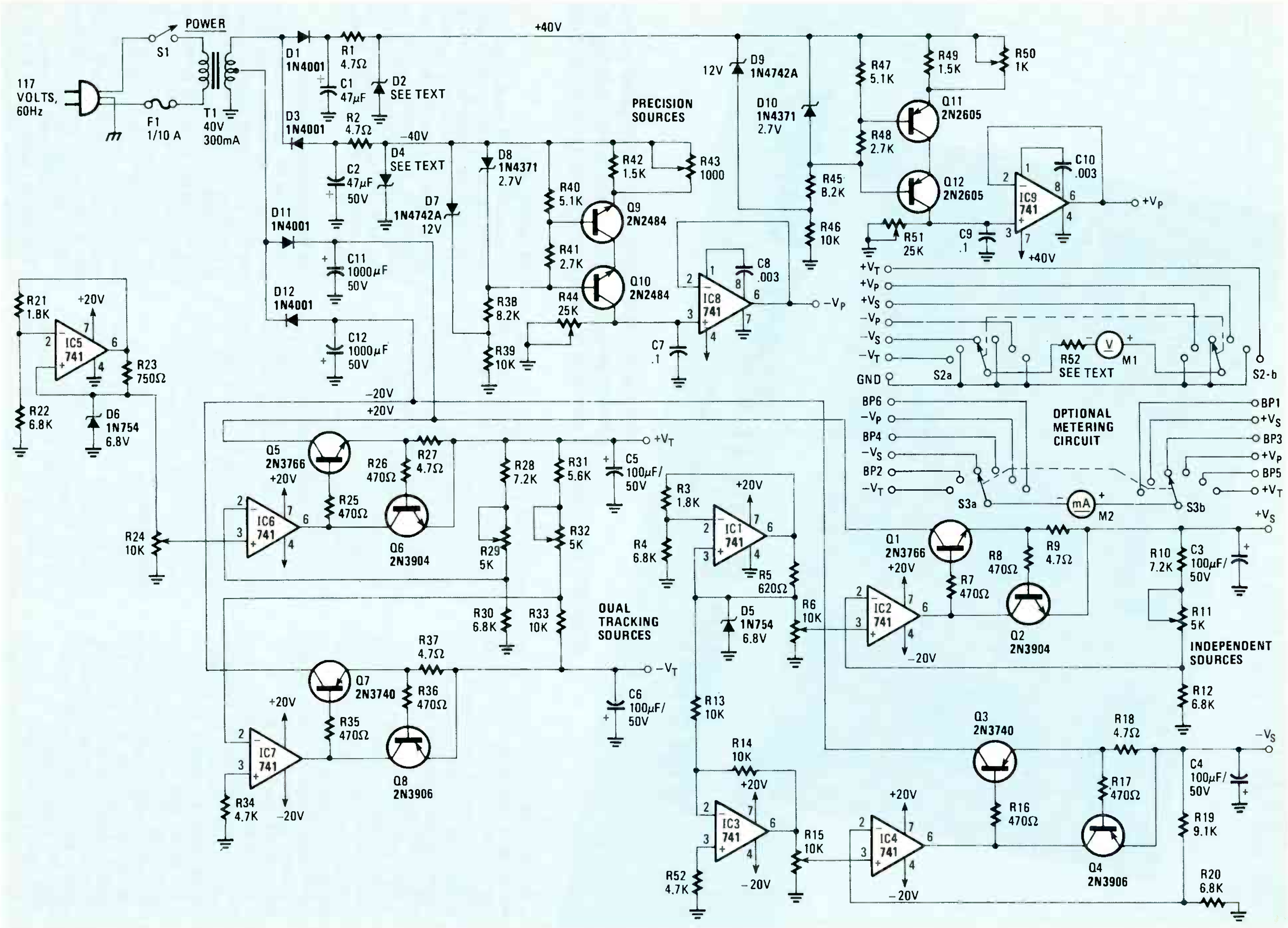
The independent supplies

Zener diode D5 provides a 6.8-volt reference to the non-inverting input of op-amp IC1. The inverting input will also be at a potential of 6.8 volts due to normal op-amp feedback. The voltage developed by IC1 is dropped across 10K potentiometer R6, the front-panel +SUPPLY control that's used to adjust the $+V_S$ output voltage. The output of R6, which may vary from 0.0 to 6.8 volts, is applied to the non-inverting input of op-amp IC2. The gain of the op-amp may be calculated using the following equation:

$$E_{OUT} = E_{IN}(R10 + R11 + R12)/R12$$

With trimmer potentiometer R11 set at its midpoint, about 2.5K, the factor in

FIG. 1—THE SCHEMATIC shows that the power supply is made up of three independent pairs of voltage sources, a rectifier circuit, and a metering circuit.



parentheses comes out to about 2.42. E_{IN} is the reference voltage dropped across potentiometer R6. So the output voltage may vary, according to the position of R6, from $0 \times 2.42 = 0$ volts to $6.8 \times 2.42 = 16.5$ volts.

The op-amps provide current limiting, and series-pass transistor Q1 provides current amplification. Transistor Q2 senses the output voltage, and, as part of IC2's feedback loop, helps compensate for variations in load current.

The negative independent supply is composed of IC3, IC4 and associated circuitry. Its reference voltage is taken from D5, the same 6.8-volt Zener used in the positive-output circuit. Here, however, the reference is applied to the inverting input of IC3. Due to the ratio of R13 to R14, that op-amp has a gain of −1. Therefore IC3 has a −6.8-volt output that is applied to front-panel −SUPPLY control potentiometer R15. From that point on, the negative circuit operates just as the positive circuit does. The output voltage is determined by multiplying the input voltage by the factor (R19 + R20)/R20. Note that PNP series-pass transistors are used here, while NPN transistors are used in the positive supply.

Dual-tracking supply

The dual-tracking supplies operate in a manner similar to that of the independent supplies. A 6.8-volt reference is derived from Zener diode D6 and applied to the non-inverting input of IC5, which functions just as IC1 does. Its output is dropped across front-panel $\pm V_T$ potentiometer R24. The output of R24 is then applied to non-inverting amplifier IC6, which functions just as IC2 does. IC7 is slaved to the output of the positive portion of the circuit, and thereby provides the tracking action that produces an output equal in magnitude but opposite in polarity.

Precision output supplies

Zener diode D9 establishes a 12-volt bias on the bases of a pair of complementary transistors, Q11 and Q12. That bias produces a constant 1-ma current through the collector circuits of the two transistors. The magnitude of that current may be adjusted by R50. The voltage developed across R51 by that current is fed to the non-inverting input of IC9, which is used as a voltage follower (an amplifier with a voltage gain of +1). Here IC9 also provides current amplification. The op-amps used in this circuit can provide a maximum current of about 4 ma.

The non-inverting input of IC9 has an input impedance of at least 10 megohms, so very little of the 1-ma current generated by transistors Q1 and Q2 leaks through that point. Of course, 1 ma through 25K potentiometer R51 will provide a 25-volt drop. As more and more of the resistance

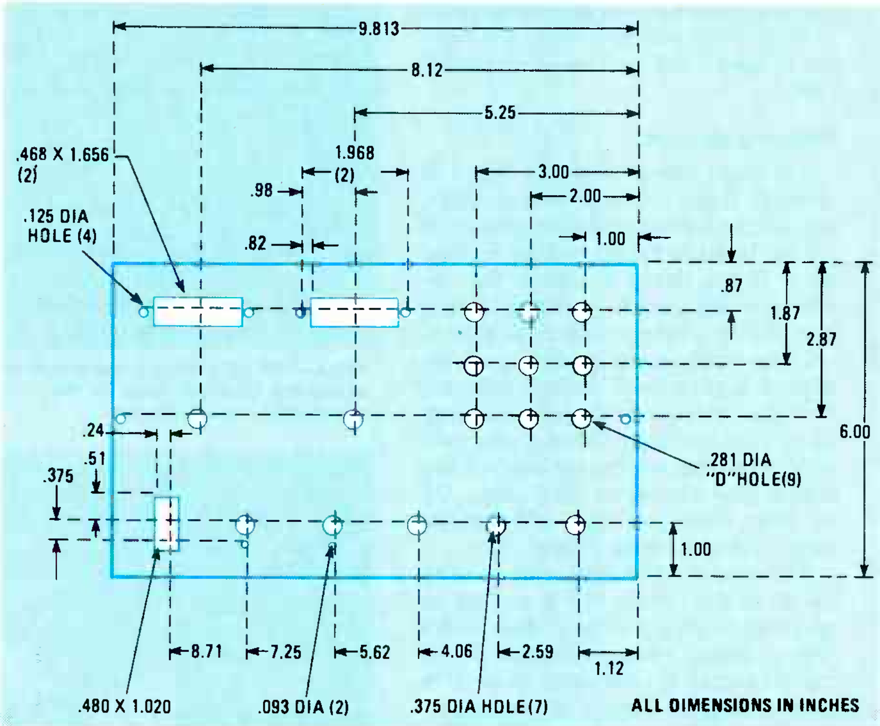


FIG. 2—FRONT-PANEL LAYOUT of the power supply. The hole-sizes for the ten-turn potentiometers and turn-counting dials you use may differ from those given here.

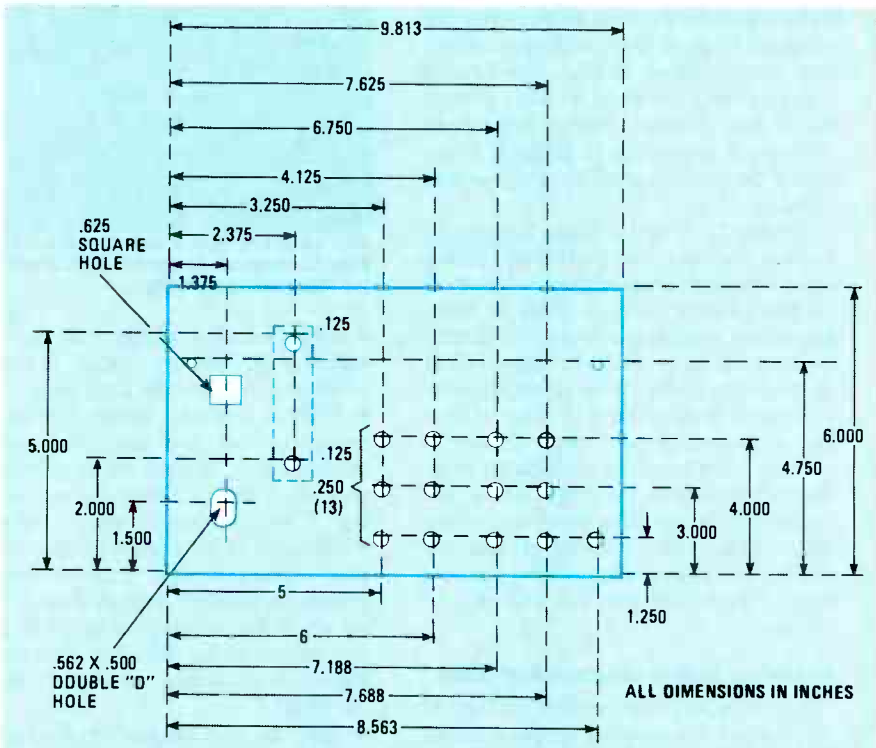


FIG. 3—REAR-PANEL LAYOUT of the power-supply. Note the small holes along the bottom for adjusting the trimmer potentiometers.

of the potentiometer is shunted to ground, the voltage presented to the op-amp decreases proportionately and so, therefore, does the output voltage. For example, when R51 measures 10K (from the non-inverting input of the op-amp to ground), output voltage would be 0.001 ma × 10,000 ohms = 10 volts.

The negative precision source is quite similar to the positive source, except that NPN transistors are used for the 1-ma current source, and the polarity of the Zener diodes is reversed. Op-amp IC8 functions as a voltage follower, as IC9 does in the positive output circuit. The output voltage is adjusted by R44, the front-panel $-V_P$

control. While R44 and R51 are specified as 10-turn 25K potentiometers, 10K units can be used if ± 10-volt outputs are sufficient.

Metering circuits

The meter circuit shown in Fig. 1 is optional. If you choose to omit all metering, just run leads from the output pads on the PC board to the appropriate binding posts. If you choose to include the current-metering circuit, understand that, with the switching arrangement shown, only one supply at a time may be used; the unused supplies will be disconnected from the binding post outputs. Although 12-position dual-gang switches were used in the prototype, you can use any switches with at least 6 positions and 2 gangs. On the other hand, you could add separate meters for each output circuit.

The value of R52 will be determined by the meter you use for M1. It will not be necessary at all if you use a meter with a voltage rating greater than that of the highest output. For the meter specified in the Parts List, a value of 1.8K is adequate, and gives a full-scale reading of 40 volts.

Construction

Most components are easily obtainable from common sources; some hints are provided for those few components which may prove difficult to find. The cabinet specified in the Parts List is roomy enough that it should allow a heftier transformer and output transistors to be used to increase the power supply's current-output capacity.

Figures 2, 3, and 4 show the dimensions of the front, rear and bottom panels of the enclosure. Although hole diameters are provided, be sure you check the manufacturer's specifications for the dimensions of the parts you'll be using before drilling. The shafts for the potentiometers will probably be either ⅛ or ¼ inch. Two-inch edge-reading meters were selected to give the front panel an uncluttered look. You can, of course, use other meters. The square hole in the back panel accommodates a rather fancy fuse holder; you may find it more convenient to use a standard round fuse holder with a 0.440-inch diameter.

Mounting potentiometers and dials

When buying components, be sure to select a dial that matches the potentiometer's shaft diameter. To mount the potentiometers and dials, refer to Fig. 5 and follow the procedure described below, adapted from instructions prepared by Beckman Instruments for the *Helipot Duodial* series of potentiometers and turns-counting dials which were used on the prototype.

- Turn the potentiometer shaft against its counterclockwise stop and insert the shaft into the shaft hole.

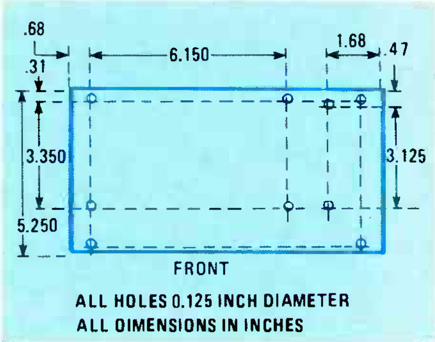


FIG. 4—TOP VIEW of the power supply chassis shows the mounting holes for the PC board, transformer, and cabinet feet.

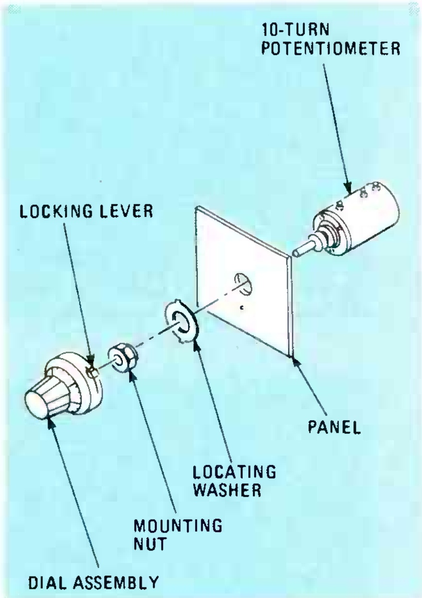


FIG. 5—MOUNTING A MULTI-TURN DIAL and potentiometer can be difficult if you don't follow the instructions carefully.

- Slip a locating washer over the shaft, and seat the locating-washer lug in the small hole beneath the shaft hole.
- With a wrench, firmly tighten the mounting nut into the potentiometer bushing. Note that the nut supplied is reversible. For thick panels, use as shown in Fig. 5. For thin panels, reverse the nut.
- With the locking lever in the OFF (up) position, slip the dial assembly over the potentiometer shaft. Be sure that the lug at the top of the locating washer seats in the slot behind of the dial. Also be sure that the whole assembly rests lightly against the panel.
- Turn the dial counter-clockwise until the zero of the outer scale is in the center of the window. Now turn the dial slowly until the scale reads between 10 and 20 at the index line. Tighten the set screw until a very slight drag on the shaft is felt. Turn the knob very slowly until both zeros line up with the index line. Tighten the set screw firmly.

The PC board

The recommended way to build the power supply is to use a printed-circuit board. Full-size foil patterns for a suitable board are shown in the "PC Service" section. (See page 83.) If you choose not to make your own board, you can purchase an etched and drilled board from the source mentioned in the Parts List. Whichever board you use, check it carefully for shorts and broken traces *before* you mount any components. Be particularly careful when you check areas that will be hidden under components

PARTS LIST

All resistors are ¼-watt, 5%, unless otherwise noted.

R1, R2, R9, R18, R27, R37—4.7 ohms
R3, R21—1800 ohms
R4, R12, R20, R22, R30—6800 ohms
R5—620 ohms
R6, R15, R24—10,000 ohm panel-mount potentiometer
R8, R16, R17, R25, R26, R35, R36—470 ohms
R10, R28—7200 ohms
R11, R29, R32—5000 ohms, 15-turn, PC-mount trimmer potentiometer
R13, R14, R33, R39, R46—10,000 ohms
R19—9100 ohms
R23—750 ohms
R31—5600 ohms
R34—4700 ohms
R38, R45—8200 ohms
R40, R47—5100 ohms
R41, R48—2700 ohms
R42, R49—1500 ohms
R43, R50—1000 ohm, 10-turn PC-mount trimmer potentiometer
R44, R51—25,000 ohm, 10-turn panel-mount potentiometer
R52—See Text

Capacitors

C1, C2—47 µF, 50 volts, electrolytic
C3, C4, C5, C6—100 µF, 50 volts, electrolytic
C7, C9—0.1 µF
C8, C10—0.003 µF
C11, C12—1000 µF, 50 volts, electrolytic

Semiconductors

IC1-IC9—LM101, or LM741 op-amp
D1, D3, D11, D12—1N4001
D2, D4—See Text
D5, D6—1N754 6.8-volt Zener
D7, D9—1N4742A 12.0-volt Zener
D8, D10—1N4371 2.7-volt Zener
Q1, Q5—2N3766
Q2, Q6—2N3904
Q3, Q7—2N3740
Q4, Q8—2N3906
Q9, Q10—2N2484
Q11, Q12—2N2605

Other Components

F1—Fuse ⅒ amp, 250 volts
S1—SPST, 115 volts AC, 1 amp
S2, S3—6-position, 2-pole rotary switch
BP1-BP9—Binding posts

Miscellaneous: Turns-counting dials (2); Cabinet: Bud No. SE3030; heatsinks for Q1, Q3, Q5, and Q7; line cord, hookup wire, etc.

Note: An etched and drilled PC board is available from Specialty Electronic Services, Inc., P.O. Box 3320, San Antonio, TX 78211, for $48.50 postpaid.

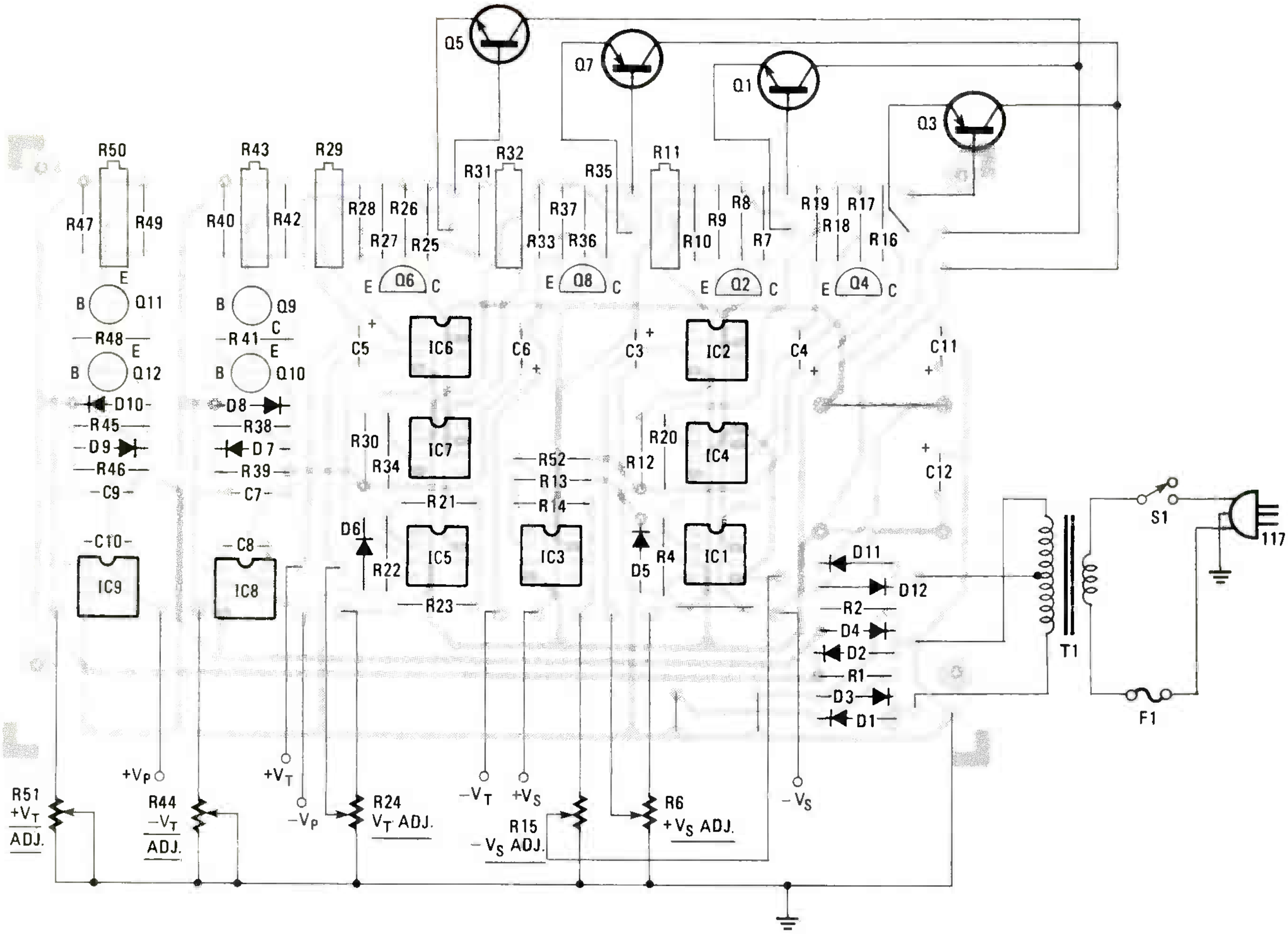


FIG. 6—PARTS PLACEMENT DIAGRAM shows how on-board and off-board components are wired.

once they're mounted on the PC board.

After checking your board and correcting any problems, you can mount the components using the parts-placement diagram in Fig. 6 as a guide. Be sure to observe the polarity of all semiconductors and electrolytic capacitors. Use sockets for the op-amps, but don't insert the op-amps at this time. Orient the small transistors (Q2, Q4, Q6, Q8-Q12) and diodes on the PC board carefully.

Transistors Q1, Q3, Q5, and Q7 require heat sinks, and should be mounted to the chassis. Be sure to use mica insulators so that their collectors won't short to the chassis; and coat the insulators on both sides with silicone grease to ensure efficient heat transfer. Attach the complete assemblies to the rear panel.

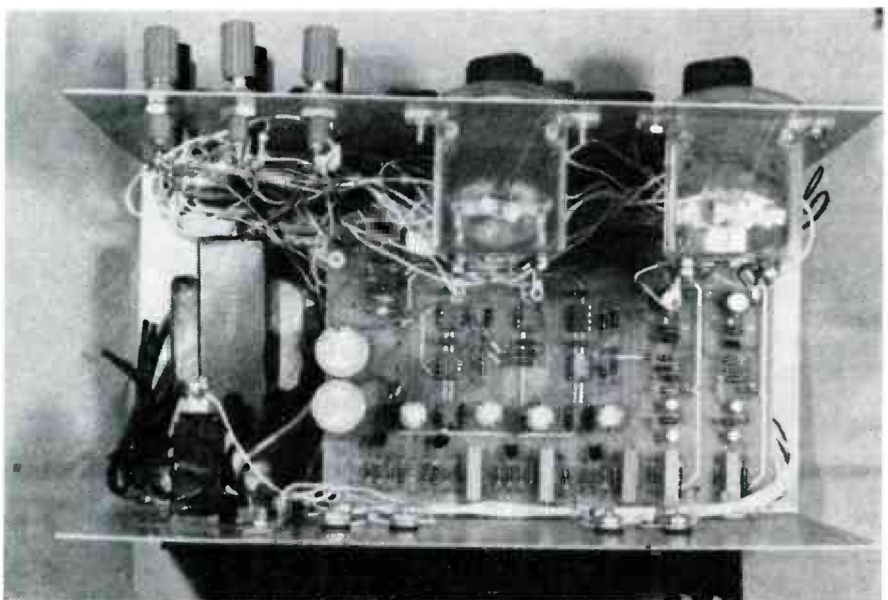


FIG. 8—INTERNAL ASSEMBLY of the power supply. M1 and M2 are shown at the upper right, and T1 at the lower left.

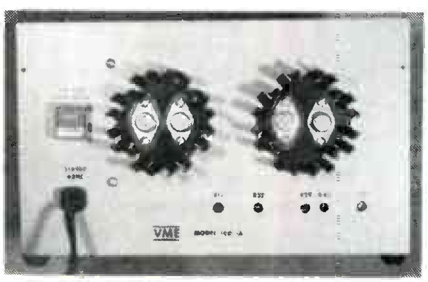


FIG. 7—THE REAR PANEL OF THE POWER SUPPLY.

Final assembly

After all components have been mounted, but before the IC's have been installed in their sockets, check the board carefully for solder bridges and unsoldered pads. Fix any problems, and then connect the transformer to the PC board. Verify the presence of +40 and

continued on page 114

A PLYWOOD Satellite-TV Dish

Can a satellite-TV dish be made out of plywood? Here's an experimental "dish" that supports the theory that says it can!

DAVID J. SWEETNAM, C.E.T.

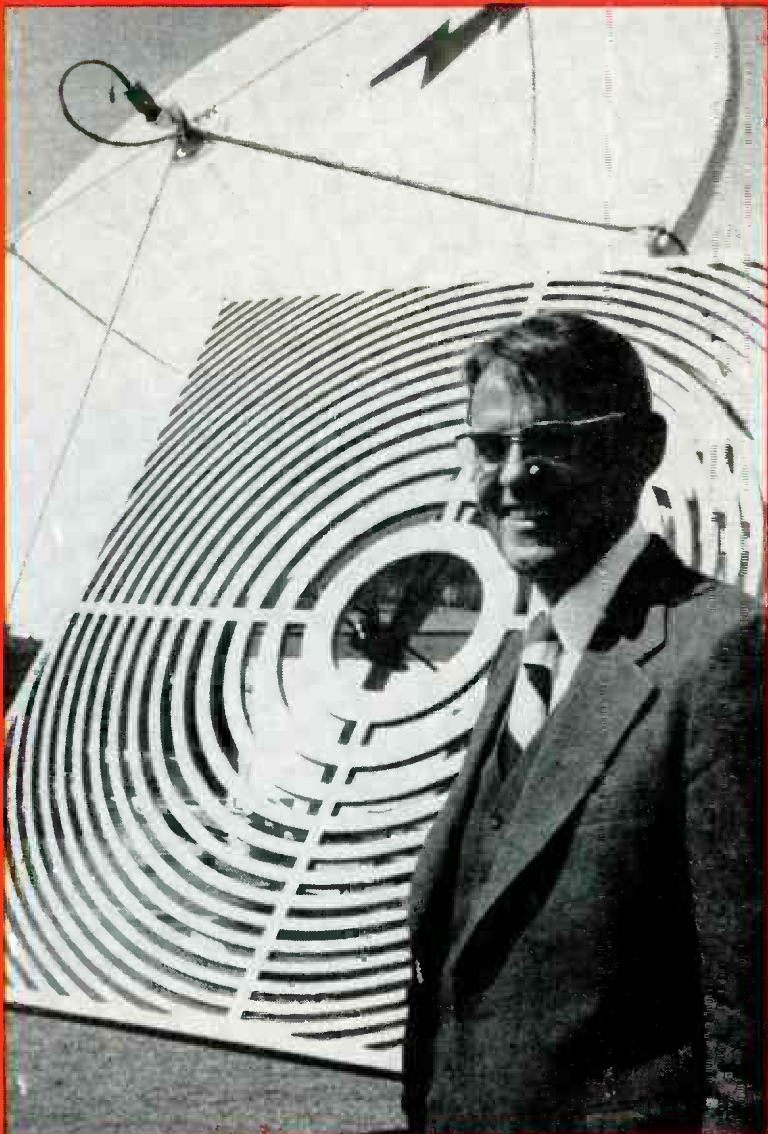
ALMOST ALL INNOVATIVE PRODUCTS come to market with a high price. But once that product develops a proven market, imitators and competitors soon appear with lower-priced products that accomplish the same task.

Consider satellite receivers, for instance. Some years back, Nieman-Marcus introduced the first such unit intended for the general public in a Christmas catalog; the cost was a "mere" $25,000. But someone quickly figured out a way to modify old radar units to do the same job for a fraction of that price. In the ensuing years, new designs and refinements have brought the cost of the satellite receiver down to under $500.

In the same vein, the traditional parabolic reflector, or "dish," used in satellite receiving setups has been challenged by other designs, such as spherical and hyperbolic dishes, and tuned Yagi arrays (which are antennas themselves, and use no dish), in an effort to reduce cost or improve performance. Rumors of yet other alternatives surface from time to time, including a persistent rumor about a "dish" built from plywood.

Well, that rumor does have a basis in fact. However, the "dish" is not a dish at all. The purpose of a dish is to concentrate the signal and focus it on the antenna, which is located inside the feedhorn. (If you are unfamiliar with satellite-TV reception systems, they were explained in a special section, "Receiving Satellite Television," that appeared in the June 1984 issue of **Radio-Electronics**.) But a dish is not the only type of device capable of concentrating and focusing a signal. Another is a lens, such as a Fresnel lens. In this article we will discuss the theory behind using a Fresnel lens as a signal concentrator, and present design criteria, as well as a short BASIC program, that will allow you to build an experimental unit using plywood.

If you're wondering why such information is not usually presented in standard antenna texts, it is because the design comes from the study of optics, not communications. In fact, there has been so little published research concerning the use of Fresnel lenses for satellite reception that the field must definitely be considered experimental. Although there are a few isolated examples of the Fresnel lens in actual use for satellite reception in Canada (British Columbia), commercial production of such lenses appears to be nonexistent.



An early TVRO lens built by Canadian scientist Dr. Bob Stewart is about the size of the dish shown in the background.

A plywood lens?

First invented by French physicist Augustin Fresnel in 1815, the lens bearing his name is commonly used in lighthouse lights, theater lights, and even flashlights. But, despite several advantages, including low cost, Fresnel lenses have found little use in microwave applications. Instead, other lenses of one sort or another have been used, including one commercial application, in the early 1960's, of a conventional lens made from styrene.

Only simple mathematics are required to understand the theory of the Fresnel lens. Central to that theory are the concepts of constructive and destructive interference. If two wavefronts of the same frequency and phase combine, then the amplitude of the resultant signal may be calculated by simply adding the amplitudes of the two waves. Here the waves are said to interfere *constructively*.

On the other hand, if two wavefronts of the same frequency, but *different* phase, combine, the amplitude of the resultant wave will be less than that of the original waves by an amount dictated by their instantaneous phases and amplitudes. In the simplest case, two waves of the same amplitude but 180 degrees out-of-phase would cancel each other out; that is, the resultant wave would have an amplitude of zero. Here the waves are said to interfere *destructively*.

Let's look at a real application. Microwave TV signals leave the satellite, and make up what can be considered to be a *uniform plane wave* at the feedhorn. If we draw a straight line at a distance F from the feedhorn (where F is the focal length of the feedhorn), we may assume that all the microwaves crossing that line will be in phase with each other. That line is labeled the EQUAL PHASE WAVEFRONT in Fig. 1.

If the wave entering the feedhorn along the horizontal axis is chosen as a reference, then waves entering the feedhorn

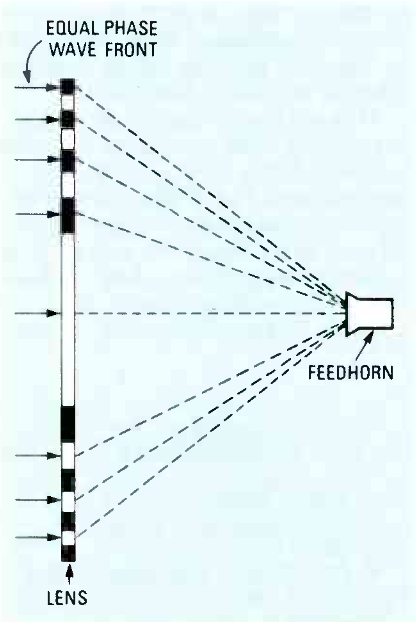


FIG. 1—MICROWAVES arriving at the lens are diffracted toward the feedhorn.

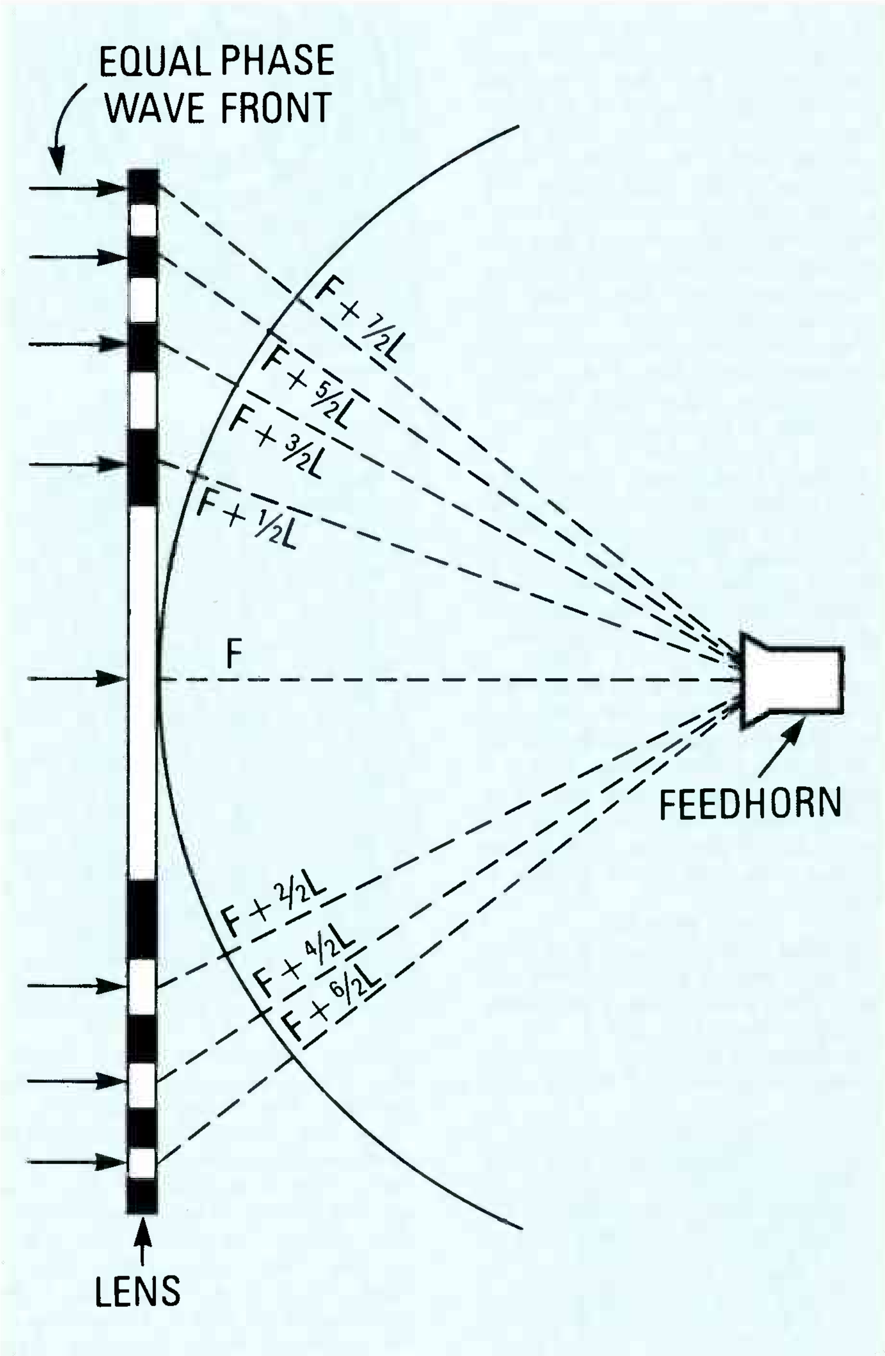


FIG. 2—DESTRUCTIVE INTERFERENCE. Waves arriving at the focal point inside the feedhorn from alternate ½-wavelength zones interfere destructively.

from above and below that line may cause destructive interference because of their phase difference. (Thanks to Huygen's principle, we can look at each point on the wavefront as a source of a secondary wave.) The phase difference is due to the increased distance the secondary waves must travel to reach the focal point. The net result is that the strength of the received signal is reduced.

Let's look at that a little closer. Divide the wavefront up into zones chosen so that, from one zone to the next, the distance from the center of each zone to the focal point increases by ½ wavelength. That means that waves arriving at the focal point from alternate zones will be 180 degrees out of phase with each other.

In Fig. 2 we have shown zones above the horizontal as being an odd multiple of ½-wavelength away from the focal point, and zones below as being an even multiple away. So the horizontal zone is at a distance of F; the first zone up is at a distance of $F + \frac{1}{2}\lambda$ (where λ is the wavelength); the first zone down is at a distance of $F + \frac{2}{2}\lambda$; and so on.

Examining the amplitude contributions from each zone at the focal point is very revealing. If the amplitude from zone 1 is A1 and the amplitude from zone 2 is A2, etc., then the sum of all contributions from the first twenty zones, A_T, is given by the equation:

$$A_T = A1 - A2 + A3 - A4 + A5 - \ldots + A19 - A20$$

Since we defined each zone to be ½-wavelength farther from the focal point than the previous zone, waves emanating from each successive zone are 180 degrees out of phase with those from the previous zone. Therefore, to obtain the amplitude of the resultant waveform at the focal point, the sum of the amplitudes of the waves from "even" zones must be subtracted from the sum of those from "odd" zones. However, the increasing angle each successive zone forms with respect to the horizontal forces us to take an additional factor into consideration. That angle causes waves from each successive zone to be weaker than those from the previous zone. Therefore, the resultant amplitude is described by the equation:

$$A_T = \tfrac{1}{2}A1$$

Fresnel's breakthrough was realizing that he could built a plate to block contributions from alternate zones, so that all waves meeting at the focal point would interfere constructively, and none would interfere destructively. So the total amplitude should be given by the equation:

$$A_T = A1 + A3 + A5 + \ldots + A19$$

Although the amplitude at the focal point without the zone plate—or lens—was only ½A1, the amplitude with the zone plate in place is almost 10 × A1—nearly twenty times the gain without the plate. In decibels, the theoretical gain, G, for the lens is shown in the following equation, where N = the number of zones:

$$G = 20\log_{10}N$$

In Table 1 we see how gain increases with the number of zones. As few as two zones give a gain of 6 dB; a twenty-zone lens gives a gain of 26 dB.

Doubling the number of zones to 40 increases the gain to 32 dB. Finally, a 160-zone lens increases the gain to 44 dB. Thus, each 6-dB increase in gain requires that the number of zones be doubled.

Note that gain varies without regard to the diameter of the lens. That differs distinctly from the parabolic dish, the gain of which is specifically related to the diameter of the dish. For a Fresnel lens with a constant outer radius, increasing the number of zones will cause gain to increase, until the zone width approaches the wavelength of the signal, at which point the lens will be essentially transparent to the signal.

However, as with a parabolic dish, lens diameter does affect *resolution*, which, in this context, is the ability to distinguish signals from one of several closely spaced satellites.

Thus far we have examined our lens only from the side. Seen from the front, the zones become a series of concentric circles, as shown in Fig. 3. That lens has 12 zones, 8 radial supports, and a gain of 21 dB. The even-numbered zones are shaded, which indicates that they are transparent to the frequencies of interest.

TABLE 1

Number of zones	Gain (db)
2	6.0
4	12.0
6	15.6
8	18.1
10	20.0
12	21.6
14	22.9
16	24.1
18	25.1
20	26.0
22	26.9
24	27.6
26	28.3
28	28.9
30	29.5
32	30.1
34	30.6
36	31.1
38	31.6
40	32.0

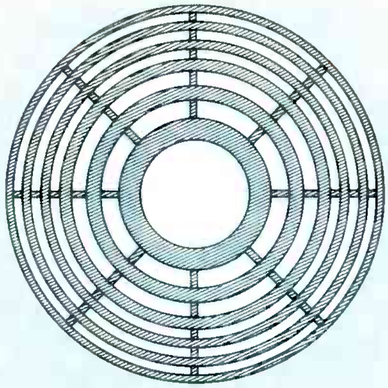


FIG. 3—FRONT VIEW of the plywood lens. The non-cross-hatched areas would be cut out of an actual lens.

TABLE 2

Radius Number	Raw Radius	Cutting Radius
R_1	$\sqrt{1}$ = 1.00	27.29 (cm)
R_2	$\sqrt{2}$ = 1.41	38.48
R_3	$\sqrt{3}$ = 1.73	47.21
R_4	$\sqrt{4}$ = 2.00	54.58
R_5	$\sqrt{5}$ = 2.24	61.13
R_6	$\sqrt{6}$ = 2.45	66.86
R_7	$\sqrt{7}$ = 2.65	72.32
R_8	$\sqrt{8}$ = 2.83	77.23
R_9	$\sqrt{9}$ = 3.00	81.87
R_{10}	$\sqrt{10}$ = 3.16	86.24
R_{11}	$\sqrt{11}$ = 3.32	90.60
R_{12}	$\sqrt{12}$ = 3.46	94.42
R_{13}	$\sqrt{13}$ = 3.61	98.52
R_{14}	$\sqrt{14}$ = 3.74	102.06
R_{15}	$\sqrt{15}$ = 3.87	105.61
R_{16}	$\sqrt{16}$ = 4.00	109.16
R_{17}	$\sqrt{17}$ = 4.12	112.43
R_{18}	$\sqrt{18}$ = 4.24	115.71
R_{19}	$\sqrt{19}$ = 4.36	118.98
R_{20}	$\sqrt{20}$ = 4.47	121.99

Designing a Fresnel lens

Table 2 shows the radii of the concentric circles used in a lens with 20 zones and an outside diameter of 244 cm, or about 8 feet. The column labeled CUTTING RADIUS shows the increasing radii of the concentric circles measured in centimeters. (We used centimeters because metric units are easier to work with than feet and inches.)

The figures shown were derived by dividing the maximum radius of the lens (in this case 244/2, or 122 cm) by the square root of the number of zones in our lens (in this case 20) to obtain a scale factor.

So if R_M is the maximum radius and N is the number of zones, the scale factor may be calculated as follows:

$$F = R_M \div \sqrt{N}$$

The scale factor for our example, then, is equal to 122/4.47 = 27.29 (the square root of 20 = 4.47). That scale factor is the radius of zone 1. To get the radius of the successive zones, multiply the square root of the zone number by the scale factor. Thus the radius of the second zone is equal to 1.41 × 27.29 = 38.48; the radius of the third zone is equal to 1.73 × 27.29 = 47.21, and so on. Note that the roots and radii are rounded off to the nearest hundredth as cutting can be no more accurate than that.

It is easy to calculate the radii of a lens with a different diameter or different number of rings, or both. Simply substitute the appropriate values for R_M and N, calculate the scale factor, and then calculate the radii of each ring.

Although the calculations are not difficult to do by hand, you may have to re-do them several times if you are experimenting with lenses of different diameters, with a different number of zones, or both. To simplify the process we have included a short BASIC program, shown in Table 3, that will do the calculations for you.

In line 70 the scale factor is calculated

TABLE 3—BASIC PROGRAM

```
10 PRINT:PRINT
20 PRINT "How many zones";
30 INPUT N
40 PRINT "What is the outside radius";
50 INPUT RM
60 PRINT
70 R1 = INT (.5 + 100 * (RM/SQR
   (N)))/100
80 PRINT "R 1";TAB(5);" 1.00";
   TAB(12);R1
90 FOR X=2 TO N
100 SX = INT(.5 + 100 * SQR(X))/100
110 RS = INT(.5 + 100 * (R1*SX))/100
120 PRINT "R";X;TAB(6);SX;TAB(12);
    RS
130 NEXT X
140 PRINT:PRINT
150 END
```

and stored in variable R1. Adding 0.5, multiplying by 100 and then dividing by 100 ensures that R1's value is rounded off correctly. The same "trick" is used in line 100, which calculates the square root of the current radius, and in line 110, which calculates its cutting radius.

After checking your calculations, mark the circumference of each circle on your working material. In order to ensure that the circles are drawn accurately, first mark off the radii of the zones; do that in several places. Then, drive a nail into the center of the lens and tie a pencil to that nail using a piece of non-stretch twine (or fishing line) so that the length of twine between the two is equal to the radius of the first zone.

Finally, inscribe the circle using the pencil. The purpose of marking the radius in several places is to ensure that the twine does not slip or stretch. If the pencil does not pass through each place where the radius has been marked, the circle is not "true" and must be redrawn. Once you are satisfied that the circle is accurate, repeat, with the length of the twine equal to the radius of the second zone. Continue in that manner until all of the needed circles are drawn.

Now you should paint the even-numbered zones and verify that your lens corresponds to the pattern shown in Fig. 3. If you are satisfied, draw in radial supports, used to hold the concentric circles of the lens together once the intervening plywood has been removed, making sure that the supports match up with any bracing on the back of the lens. (If the lens is large enough that it must be built using two sheets of material laid side-by-side, the two sheets must be tied together using radial braces.) Paint those radial supports as well, and before cutting, again verify that your lens corresponds to that shown in Fig. 3.

Finally, carefully cut out and remove the odd-numbered zones; Be sure that you don't also cut out the radial supports! If you have followed the directions above, then only the *unpainted* areas should be removed. To complete the lens, it will be necessary to cover it with metallic paint to keep the satellite signal from passing through the even-numbered zones, defeating its purpose. Several coats of a good quality aluminum paint should provide adequate shielding, as well as some weather-protection.

Calculating focal length

While the paint is drying, you can begin figuring out where the lens' focal points lie. In order to do that, you will have to calculate the focal point of the lens.

Assuming that you are interested in receiving C-band signals, the downlink frequencies vary between 3.700 GHz and 4.180 GHz, depending on the transponder. In order to calculate the required focal length, we need to know the wavelength of the downlinked signals. That is found by dividing 30 by the frequency, f, where f is measured in GHz:

$$\lambda \text{ (cm)} = 30/f$$

Wavelength varies from about 7.18 to 8.11 cm for those frequencies. The focal length, or distance from the lens to the feed point, for a Fresnel lens is given by the formula:

$$F = (R1)^2/\lambda$$

where R1 is the radius of the inner-most circle in the lens, and F is the focal length. You may calculate focal length in any desired units (feet, inches, centimeters); just be consistent. If you specify wavelength in centimeters, then R1 must also be in centimeters; of course, the final result will also be in centimeters.

The focal length of the lens described in Table 1 will range from 91.83 cm for transponder 1 to 103.72 cm for transponder 24. The center of that band falls at 97.28 cm. That is the focal length that is used for our set up. Note that the variation on either side of that center frequency to the band edges is 5.95 cm; the total variation is 11.9 cm. Most commercial waveguides have that much depth. Thus, to ensure that all of the focal lengths fall within the area of the waveguide, all that needs to be done is to measure back 5.95 cm from the waveguide opening, mark that point on the case, and mount the feedhorn so that that point is 97.28 cm from the lens.

TV satellites are all located in a geostationary orbit some 22,279 miles above the equator; that orbit is known as the Clarke belt. To aim the lens, you have to find where in the sky the Clarke belt lies relative to your location. That is done in the same manner as with a parabolic reflector. If you are not familiar with the procedure, see "Installing your own TVRO" in the June and July 1985 issues of **Radio-Electronics**.

In tracking between satellites in the Clarke belt, The Fresnel lens offers one major advantage over parabolic dishes. With dishes, the entire dish and feed assembly must be moved when you wish to focus on a different satellite. That's because such a parabolic dish can only focus on one object at a time. But a Fresnel lens can focus on several objects at a time, each with its own focal point. Thus to receive a different satellite, all that needs to be done is to move the feed to the appropriate focal point. Once you have your lens aimed at the right region of the sky, you'll have to experiment to see how many satellites you can focus on, and where their focal points fall. (When doing so remember that each focal point will be at the focal length of your lens.) If you wish to receive satellites located at the extreme ends of the belt, you can re-aim the entire lens-and-feed assembly, much as you would a standard parabolic reflector.

Other considerations

The lens requires the same sort of strong, vibration-free mount used for quality parabolic dishes. Also, care should be taken to ensure that the focal point is not obstructed by any mounting apparatus, or the edge of the feedhorn.

To decide if a Fresnel lens is suitable for your application, you should consider two things. First, as we saw above, the gain of the lens is a function of the number of zones. Material limitations will probably restrict the number of zones to less than 80, and that limits your gain to something under 38 dB; as a comparison, that's roughly the gain of a 6–8-foot dish. Of course, the fewer the zones, the lower the gain.

What that means, of course, is that a top-quality LNA, one with an exceptionally low noise-temperature rating, will be required for best results at any location. In addition, if you happen to be located in one of the "fringe" reception areas (such as New England or Florida), it is likely that you will only be able to receive the strongest transponders.

Second, as we mentioned earlier, lens resolution depends strongly on lens diameter. As a rough rule-of-thumb, figure that the lens will have to be as large as the parabolic reflectors that work well in your area. You may want to experiment a bit to find an appropriate diameter for your lens. Fortunately, working with plywood makes such experimentation relatively cheap.

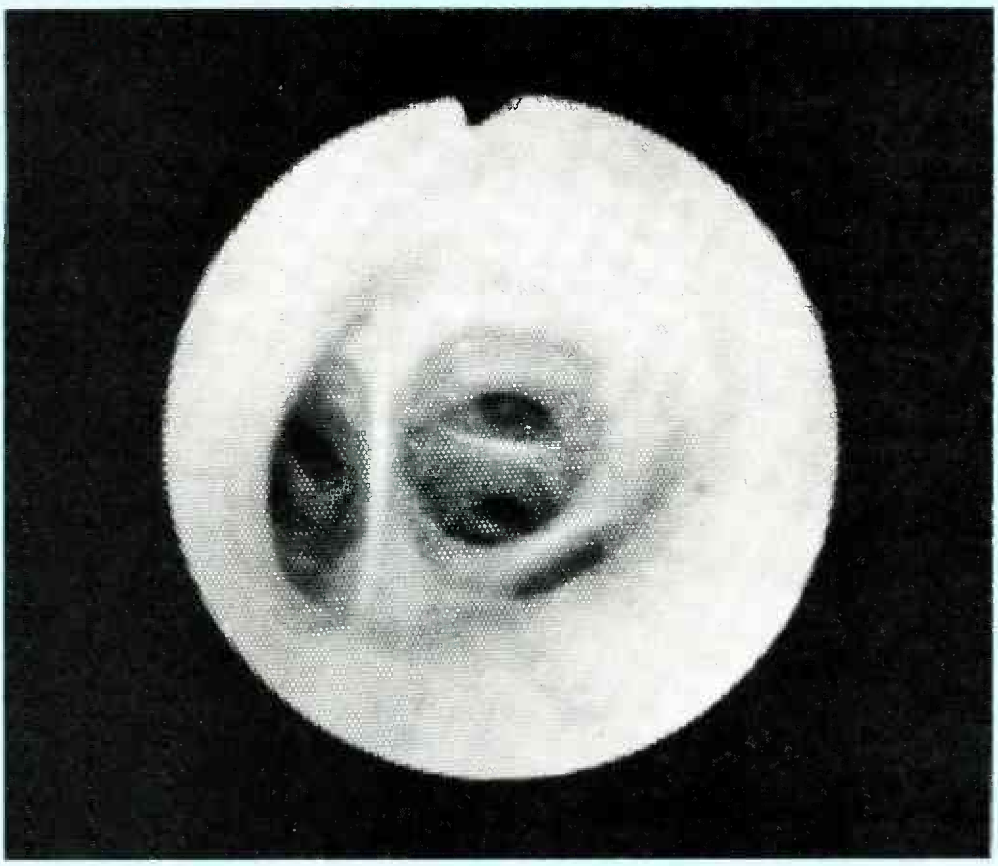
As you may have guessed from the theory section presented earlier, blocking out either the even or the odd numbered zones will produce the same gain. In areas of bright sunlight, you might want to cut out the even zones and leave the odd zones, including the center zone, in place. That will prevent radiation from the sun from entering the feedhorn directly. If you do build your lens in that manner, remember that you must design it so that it has an odd number of zones (i.e. 21 instead of 20).

The lens has more than one focal length. There are increasingly fainter images at F/3, F/5, and F/7, but they are of quickly diminishing intensity due to an increasing amount of destructive interference.

The lens may be built from materials other than plywood. The thinner the material the lens is made of, the closer its gain will be to the theoretical. The only restriction is that the material must be able to withstand local weather conditions, as well as be opaque to microwave frequencies. We have specified plywood (covered with aluminum paint), but screen mesh with ⅜-inch or smaller holes could be used. In addition, sheet metal or aluminum-covered fiberglass or plexiglass could be used. **R-E**

ELECTRONICS IN MEDICINE

RAY FISH, Ph.D., M.D.



Lasers and fiber optics play an important part in modern medical care. Learn more about them, and the techniques they make possible, in this article.

INSTRUMENTS THAT USE OR MAKE USE OF light have always been important in medicine. Optical instruments such as otoscopes (used to examine the ear) and opthalmoscopes (used to examine the eye) are found in nearly every doctor's office. Now, new technologies and techniques have made optical instruments more important and useful than they have ever been before. Such optical devices now run the gamut from simple flashlights to complex systems that use laser light to perform surgery on microscopic blood vessels in the back of the eye.

The nature of light

The phenomenon known as light is a type of electromagnetic radiation, differing from, say, radio waves only in wavelength. Figure 1-*a* shows the region of the electromagnetic spectrum that ranges from radio waves to ultraviolet light. As is shown there, the region of electromagnetic radiation that is "visible" to the human eye is relatively small. Figure 1-*b* shows the spectrum of visible light in more detail.

As you can see from Fig. 1, colors differ from each other in wavelength. In humans, three types of color-sensitive photoreceptors in the rear of the eye are used to discern different colors. One type is most sensitive to red light. The farther a color is from red, the less sensitive the red light photoreceptor will be to it. The two other types of photoreceptors are sensitive to blue and green, respectively. Light of different wavelengths stimulate each of those three photoreceptors differently. The degree of stimulation is then converted by the brain into a multicolor image. (As an analogy, consider the way a color-TV uses just the three phosphor colors in

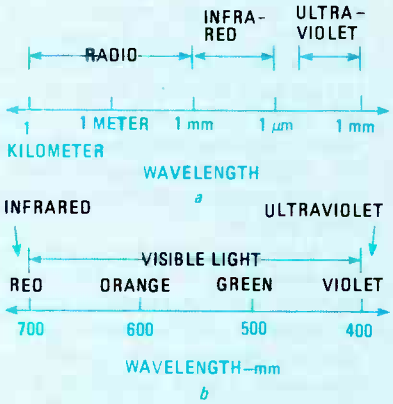


FIG. 1—THE ELECTROMAGNETIC SPECTRUM. As is shown here, only a small range of wavelengths is visible to the human eye.

the CRT—red, green, and blue—to generate a multicolor image. It is done by varying the intensity of the different color phosphors in a region.)

Using light

Previously we saw how the oxygen content of blood could be determined by shining a light through an earlobe and analyzing how different wavelengths are absorbed (see the May 1985 issue of **Radio-Electronics**).

In the laboratory, an instrument called the spectrophotometer uses the same principal. Chemicals in a liquid solution are analyzed by finding how much absorption of light occurs over a range of wavelengths.

As shown in Figure 2, light is passed through a prism. As the light source and prism are rotated, different colors of light get through the slit. A photocell detects the light transmitted through the solution being analyzed at every wavelength. Corrections are made to take into account the absorption caused by the sample holder, etc., and the results are plotted as shown in Fig. 3. As every chemical and compound absorbs light in a different way, the information obtained from a spectrophotometer can be used to accurately identify the contents of the sample being analyzed.

Lasers

All electromagnetic radiation is periodic in nature; that, of course, includes light as well as radio waves. Thus, just as we can talk about the phase of a radio signal, we can talk about the phase of radiated light. In ordinary light, each atom or molecule of the light source emits its radiation independently. As such, the phase of the light radiation emitted by each atom or molecule is unrelated to the phase of the light radiation emitted by any other atom or molecule in the source.

In a laser, on the other hand, the atoms and molecules of the source are forced to radiate in phase. (Laser, by the way stands for *L*ight *A*mplification by *Stimulated E*mission of *R*adiation.) Because of that, the timing and physical spacing of the light radiated by each atom or molecule is coordinated in such a way that the electromagnetic waves of the light reinforce each other. The resulting light is said to be coherent—the light emitted from each source has spatial and temporal coherence.

The device used to generate laser light is called a laser. Lasers use many different materials, including gases, liquids, and solids as a light source. Gas lasers use a gas (or mixture of gases) in a glass tube. Commonly used gases are helium-neon, carbon dioxide, argon, and krypton. Liquid lasers use organic dyes. The familiar ruby laser uses a solid as the lasing medium. For a light source, that laser uses chromium uniformly distributed throughout a rod of crystalline aluminum oxide. The output of the laser is light with a wavelength of 694.3 nanometers, a deep red color.

The light generated by a laser can be characterized by several parameters:

- Wavelength
- Type of emission—continuous or pulsed
- Energy
- Power density
- Beam divergence

Lasers in medicine

Lasers are used most widely for eye-

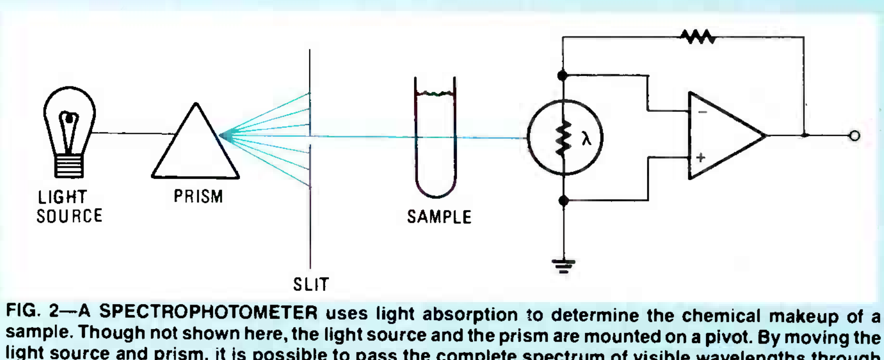


FIG. 2—A SPECTROPHOTOMETER uses light absorption to determine the chemical makeup of a sample. Though not shown here, the light source and the prism are mounted on a pivot. By moving the light source and prism, it is possible to pass the complete spectrum of visible wavelengths through the sample.

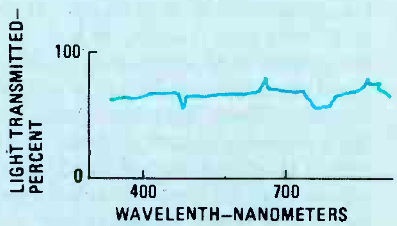


FIG. 3—THE OUTPUT of a spectrophotometer. By plotting the amount of light transmitted at various wavelengths, it is possible to uniquely identify the contents of a sample.

surgery. Most other uses (and some of the eye surgery applications) are still considered to be somewhat experimental. Many uses of the laser in medicine are very promising, but are still considered by many to be unproven, and too expensive. Many applications have worked out well in clinical trials, but are not yet accepted by the government or medical community as having been proven to be more effective than other techniques. The question of safety is also significant: Light strong enough to affect tissues can burn the skin or cause blindness if reflected into the eye. The heat generated by a laser can cause explosions when certain gases are present.

Lasers are used in a variety of different applications. For instance, laser light can be used to seal off bleeding blood vessels in a stomach ulcer or be focused to a 50-micron beam for use in eye surgery.

A laser cuts by heating tissues. That causes the tissue to be vaporized. The vaporized area is surround by a thin layer of heat coagulated tissue in which blood vessels smaller than one millimeter are sealed. Thus, problems with bleeding are minimized.

The wavelength (color) of the laser light can be chosen to be absorbed in certain tissues or organs, and not by others, making heating more selective. For example, almost all soft tissues strongly absorb the energy of the carbon dioxide laser, which is in the mid-infrared portion of the spectrum. If such a laser is directed at the eye, the cornea will be damaged. The light of the argon laser, on the other hand, is in the visible region (blue-green) and will pass through the lens and cornea of the eye. Almost all of the energy will go to the retina and cause heating there.

Laser light can be directed to a particular area in much the same way that regular light can. That means that fiber optics or a system of mirrors and lenses can be used. For laser eye surgery, an elaborate optical system is used to focus light onto the retina in the back of the eye. The physician sees a spot of light superimposed on the image of the retina so that the area to be operated upon can be chosen. Once that is done, a laser can be used in a variety of ways. For instance, it can be used to seal tears in the retina. Lasers can also be used to seal off abnormal blood vessels in the back of the eye. Abnormal blood vessels that are likely to bleed are a common feature of several eye diseases. Those bleeding blood vessels are a relatively common source of blindness. Less than a drop of blood leaks into the eye from the abnormal vessels, but the blood covers the light-sensitive retina. Using the laser, abnormal blood vessels can be identified and sealed off before they bleed.

Surgery on other parts of the body can also be performed using the laser. Vocal-cord surgery using the laser has proven to be useful. A laser is focused on tumors of the vocal cords. The tumors are burnt off. There is usually no bleeding because blood vessels feeding the area are cauterized (burned shut).

Cancer farther down, in the airways of the lungs, can also be reached by the laser. Unfortunately, such surgery is not done in very many centers. The procedure would benefit a large number of people, however, because many patients with lung cancer are smokers who do not tolerate surgery well because of coexisting lung and heart disease.

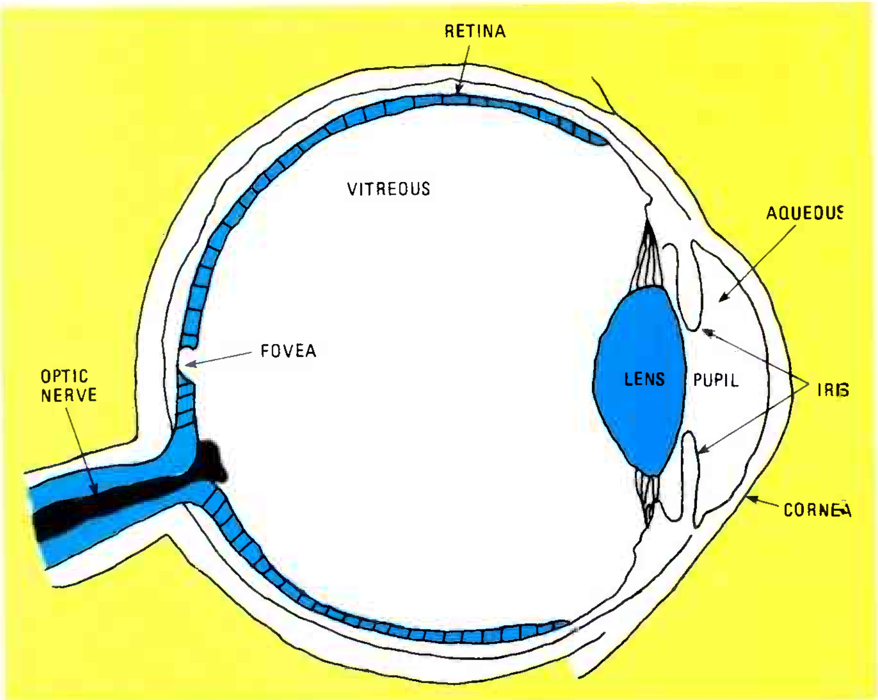


FIG 4—CROSS SECTIONAL VIEW OF THE EYE. Light passes through the normally transparent cornea (solid), aqueous (liquid), lens (solid), and vitreous (gel). When light strikes the retina, electrical signals are initiated and transmitted to the brain via the optic nerve.

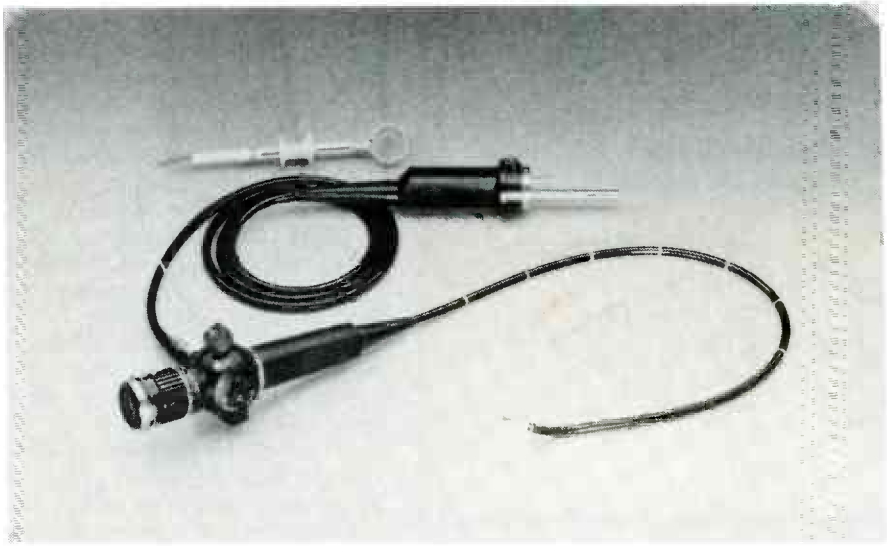


FIG. 5—A FLEXIBLE ENDOSCOPE. Such a device allows a doctor to view and have access to regions deep within the body.

Lasers are used in dermatology to treat skin lesions. For example, carbon-dioxide lasers produce light in the infrared region. Such light penetrates only to a depth of .1 mm or so. Depending on the focus of the beam, such a laser either cuts or vaporizes the skin. When used to cut, the area is sterilized. Blood vessels, nerves, and lymphatic channels are sealed off. When used to vaporize tissue, it is possible to remove skin cancer, warts, and other lesions.

Lasers have also been used to treat bleeding and tumors in the esophagus, stomach, and upper intestine (those make up the upper gastrointestinal tract). To do that, the light from a neodymium:yttrium aluminum garnet (artificial diamond) laser (referred to as an Nd:YAG laser) is brought to the area of interest by a quartz fiber optic channel in an endoscope (that instrument will be described shortly).

Laser safety

There are many dangers associated with working with lasers. Some lasers produce enough concentrated energy to burn the skin or damage the eye. Once you "see" the light generated by a laser, it may already be too late to prevent eye damage. Thus, precautions must be taken before injury occurs.

The ultraviolet and far infrared light generated by many lasers is absorbed by several of the structures of the eye (see Fig. 4). If the light is absorbed, of course, its energy is turned into heat. The result will be a burn in the area of absorption. That results in cataracts forming if the lens is involved, or damage to the sensitive structures at the rear of the eye if the light falls on the retina. Loss of vision could easily result if the laser is powerful enough.

Fortunately, safe power levels have been defined, and low-power lasers can be used safely without eye protection for many applications. Some lasers, such as gallium-arsenide lasers, are considered safe to use without eye protection. For other lasers, protective eye guards and glasses are available.

Even more dangerous than the light they produce are the power levels associated with lasers. Power supplies for those devices often provide tens of thousands of volts. Needless to say, a knowledge of high-voltage circuits, and a healthy respect for the same, is required before attempting any type of laser service or maintenance.

Endoscopy

Endoscopy is the viewing of areas within the body. Instruments, called endoscopes (see Fig. 5), exist that allow physicians to look inside the stomach, intestines, bladder, lung, abdominal cavity, and joints. Endoscopes fall into two

continued on page 111

A VERSATILE REMOTE CONTROLLER

Adding remote control to any circuit or device is not as hard as you might think. This article shows you how its done.

J. DANIEL GIFFORD

THE DREAM OF ADDING REMOTE CONTROL to appliances, gadgets, and projects is an old one in electronics. But because of the complexities involved, it is one that has been beyond the skills of many hobbyists. Now, as in so many other areas of electronics, *L*arge *S*cale *I*ntegration (LSI) IC's have come to the experimenter's rescue.

The Motorola MC14457 remote control transmitter and MC14458 remote control receiver IC's, by themselves, form almost 90% of a high-quality infrared or ultrasonic remote-control system that is capable of handling up to 272 commands. Although the IC set was developed for television remote use, and has some special pin functions for that purpose, it is highly flexible and can be used for a myriad of remote-control needs ranging from controlling TV and stereo gear, to remote arming of security systems, to remote programming of computers and robots.

The remote-control system

The MC14457 IC (see Fig. 1) needs only a keyboard, oscillator, output device, and battery to form a complete remote-control transmitter. Similarly, the MC14458 receiver (also shown in Fig. 1) needs only a power supply, input circuit, and oscillator to function. Both devices are CMOS, and thus require only a minimal amount of supply current.

The transmitter does not have or need an on/off switch. When a button on the keyboard is pressed, the clock oscillator starts up, the key is decoded, and the correct seven-bit data stream is transmitted via either an array of IR LED's or an ultrasonic transducer. Four of the transmitted bits are actually either data or a command; a fifth "function" bit lets the receiver know the nature of those bits (the function bit is not externally available). Two start bits are added to synchronize the transmission with the receiver. Table 1 shows the 32 possible keys, their codes, and their row/column location.

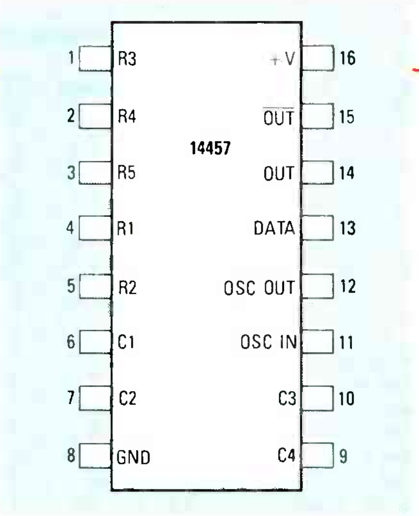
The data is transmitted in FSK (*F*requency *S*hift *K*eying) format, using two frequencies divided down from the 500 kHz control clock—38.46 and 41.66 kHz. That FSK transmission, other than using much higher frequencies, is similar in operation to the encoding process used by computer modems.

The 14458 receives the transmitted data through either a photodiode or an ultrasonic transducer, After the signal is amplified and conditioned, the receiver IC decodes it from its FSK form and, according to the state of the function bit, routes it to either the data or the command port.

If the function bit is a 0, the four bits are read as data and are routed to the data port. The data port is two digits wide (each digit is made up of eight bits), and can be configured to accept either one or two digits as a full data word. After a full word is transmitted, a pulse appears on the data available (DA) pin. The data can be either BCD or hexadecimal in format, depending on the number of keys used in the transmitter, so data words from 00 to 99 (0 to 9 in single digit mode) or 00–FF (0–F) can be transmitted to the data port.

If the function bit is a 1 instead of a 0, the four data bits are read as a command, and are routed to the command port. A received command is latched into the 4-bit port, after which a pulse appears on the valid command ($\overline{VC}$) pin. Of the commands, four are internally decoded by the 14458, and twelve require external decoding to be useful.

With 256 data words and 16 commands, plus other specialized single-pin



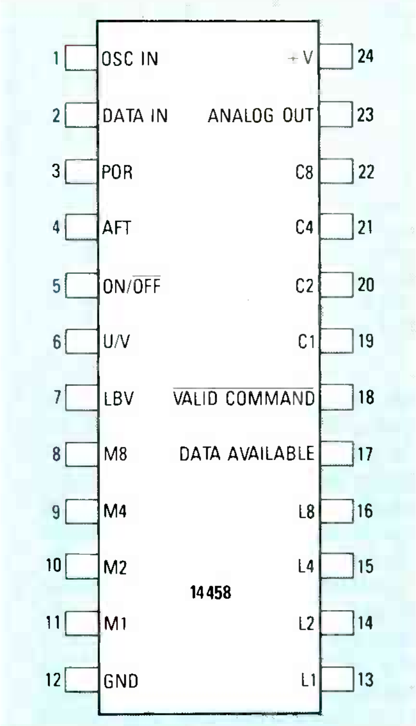


FIG. 1—THE 14457 REMOTE-CONTROL TRANSMITTER IC pinout (top) and the 14458 remote-control receiver IC pinout (bottom). With the addition of a keyboard, oscillators, power supplies, and input and output transducers, the pair of IC's becomes a powerful remote-control system.

TABLE 1—4457/4458 COMMAND ENCODING

Key	Row	Column	FE	C8	C4	C2	C1	$\overline{VC}$ Pulse
0	1	1	0	0	0	0	0	
1	1	2	0	0	0	0	1	
2	2	1	0	0	0	1	0	
3	2	2	0	0	0	1	1	
4	3	1	0	0	1	0	0	
5	3	2	0	0	1	0	1	
6	4	1	0	0	1	1	0	
7	4	2	0	0	1	1	1	
8	5	1	0	1	0	0	0	
9	5	2	0	1	0	0	1	
TOGGLE 1	1	3	1	0	0	0	0	X
TOGGLE 2	1	4	1	0	0	0	1	X
CONT 1	2	3	1	0	0	1	0	X
CONT 2	2	4	1	0	0	1	1	X
CONT 3	3	3	1	0	1	0	0	X
CONT 4	3	4	1	0	1	0	1	X
ANALOG DOWN	4	3	1	0	1	1	0	X
ANALOG UP	4	4	1	0	1	1	1	X
MUTE	5	3	1	1	0	0	0	X
OFF	5	4	1	1	0	0	1	X
A	2/5	1	0	1	0	1	0	
B	2/5	2	0	1	0	1	1	
C	3/5	1	0	1	1	0	0	
D	3/5	2	0	1	1	0	1	
E	2/3/5	1	0	1	1	1	0	
F	2/3/5	2	0	1	1	1	1	
CONT 5	2/5	3	1	1	0	1	0	X
CONT 6	2/5	4	1	1	0	1	1	X
CONT 7	3/5	3	1	1	1	0	0	X
CONT 8	3/5	4	1	1	1	0	1	X
CONT 9	2/3/5	3	1	1	1	1	0	X
CONT 10	2/3/5	4	1	1	1	1	1	X

outputs controlled by the data sent to the two ports, it's easy to see how that IC set can be used in dozens of different ways. By proper use of the data and proper decoding of the commands, almost anything that can be done with switches and knobs can be done over an invisible beam. The only limitation on the usefulness of the 14457 and 14458 is how well you can interface the receiver to the device under control. Before we get into the problems of interfacing and decoding, let's look at how a complete transmitter and receiver are built.

The transmitter

Since the 14457 is CMOS, it draws almost no supply current by itself. However, the clock oscillator and the output device are another story—the current drawn by both would normally make battery power impractical. However, the 14457 is designed to shut down the oscillator when it is not needed and the output circuitry draws power only when transmitting, which takes 0.1 seconds per data stream. Those features make both battery power and the lack of an on/off switch completely practical.

Being CMOS, the 14457 can operate from a supply voltage between 5 and 12 volts. The voltage and type of battery used will depend on the type of output. Since the ultrasonic type needs a higher voltage but much less current than the IR type, an ordinary 9-volt transistor battery can be used for power. The array of IR LED's, on the other hand, need a substantial amount of supply current, so four "AA" or "AAA" cells in series (for a total of 6 volts) should be used. In both Figs. 2 and 3, note that a diode is used to prevent damage to the IC from reversed battery connections and a 50-µF capacitor is used to filter transients from the supply line; those components should not be omitted.

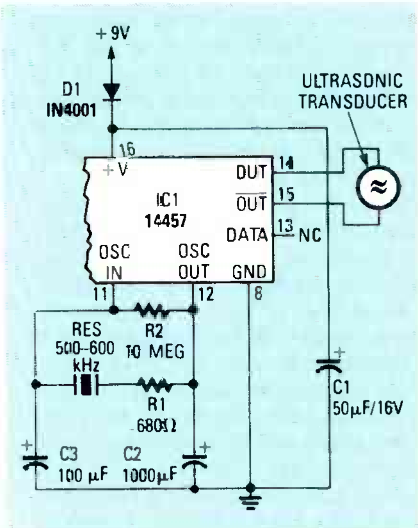


FIG. 2—THE BASIC CONNECTIONS for the transmitter oscillator. Note that this circuit uses an ultrasonic output.

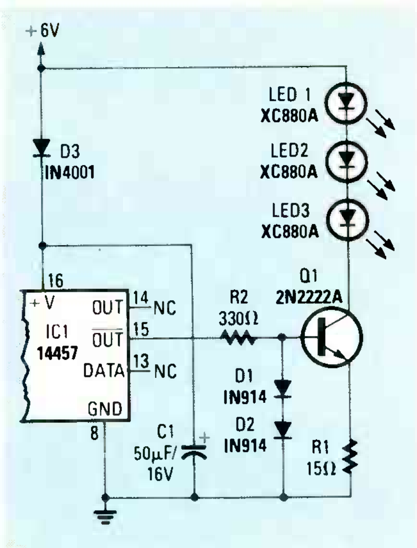


FIG. 3—THE OUTPUT CIRCUIT for an infrared transmitter.

The 14457 has an on-board oscillator circuit; the only external parts required are the frequency-determining components. Both the 14457 and 14458 require an identical control frequency of about 500 kHz. Instead of using a crystal to maintain the frequency, both units use a much cheaper, smaller, and more durable ceramic resonator. While ceramic resonators are less precise than crystals, they are more than accurate enough for many uses, this one included. The exact frequency of the resonators used is not important, as long as they are identical and of about the frequency specified. Suitable resonators are available from the source provided on page 67 (Ordering Information).

The ceramic resonator is used in exactly the same manner as a crystal (Fig. 2), requiring a tank circuit around it to force it to oscillate at the correct frequency. High-Q disc capacitors and metal-film resistors should be used in the tank circuit to promote stability. Note that the 14457 disables the oscillator by clamping pin 11 (OSC IN) to ground.

The output circuit of the ultrasonic transmitter is simpler than that of the IR type and requires no circuitry in addition to the ultrasonic transducer itself. The 14457 uses complementary push-pull outputs to generate a strong, balanced drive signal across the transducer.

The IR output uses only one of the two outputs, since a driver transistor is needed to provide sufficient current to the LED array. Three infrared LED's are used to increase the range of the transmitter. High-output LED's such as XC880A's or TIL906-1's should be used.

There is no real difference in performance or range between the two types of output. The IR output is decidedly cheaper, since a pair of ultrasonic transducers can cost $25.00 or more, and the parts are more widely available. On the other hand, the IR beam is limited to line-of-sight

Ordering Information

The following are available from Circuit Specialists, PO Box 3047, Scottsdale, AZ 85257: 14457/14458 transmitter/receiver pair, $17.00 postpaid; 455-kHz ceramic resonator (Mallory CU455), $8.50 each, postpaid.

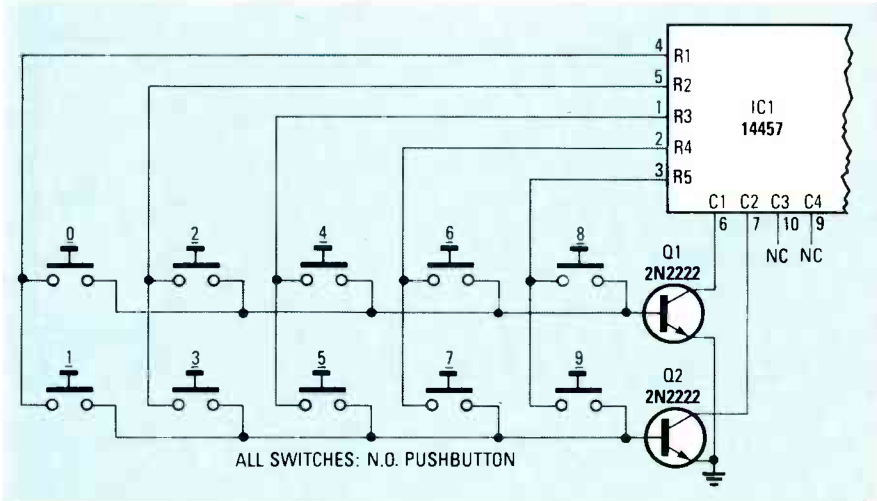


FIG. 5—THE 10-KEY keyboard. Each SPST normally-open switch shorts one row to one column. Note that the column 3 and 4 pins are left unconnected.

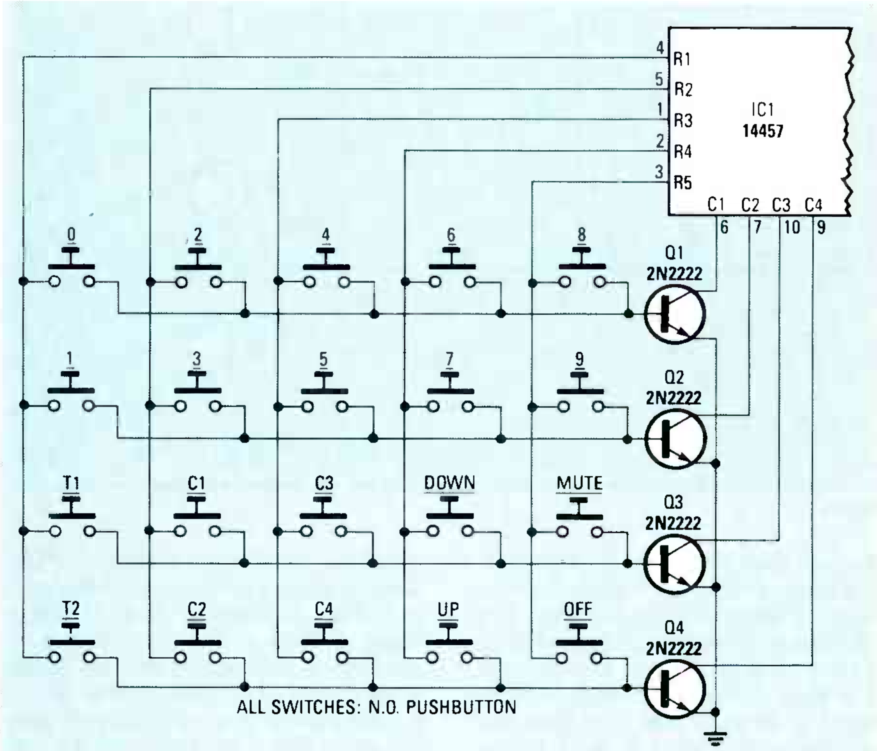


FIG. 6—THE 20-KEY keyboard. Either discrete transistors or an NPN IC array can be used.

operation, while the ultrasonic signal can bend around corners and other obstacles. In general, the IR type is recommended for hobbyist use.

Besides the push-pull transmitting outputs, the 14457 has another output, the DATA output, that can be used to give a visual indication of transmission. It follows the unencoded binary data used to modulate the FSK transmission. If a driver circuit and LED like that in Fig. 4 are added, the LED will flicker briefly each time data is transmitted. That load will contribute slightly to battery drain, but since it is impossible to see infrared or hear ultrasonics, the feedback of a visual transmission signal could be valuable.

The most difficult part of building the transmitter is the construction of the keyboard. The 14457 has four column and five row inputs, each with its own internal pull-up resistor. To transmit a data digit or command, one column and one (or more) rows must be simultaneously shorted to ground. The problem is that only one type of row-to-column-to-ground keyboard is commonly available, and it is for telephone use, and it has the familiar 12-button pattern. Since that type of keyboard is expensive and difficult to modify to the circuit needed here, it is not practical.

Fortunately, there is an alternative. The ordinary row-to-column type of matrix keyboard may be used with an array of NPN transistors to provide a path to ground. That allows use of the common, inexpensive membrane-type keyboard like that found in many calculators. The NPN transistors may be discrete 2N2222/2N3904 types, or a DIP array such as the CA3046/3086.

Actually, any type of SPST normally open switches could be used to build a keyboard, with one connection of each switch going to the correct row and the other going to the correct column. Although that type of keyboard will be more expensive and much larger than the membrane type, the keys can be laid out in any desired pattern.

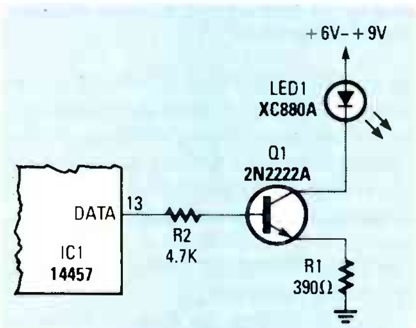


FIG. 4—THIS CIRCUIT can be added to give a visual indication of the transmitted signal.

The 14457 allows the use of up to 32 keys, 16 for the data digits Ø through F, and 16 for commands. Any of those keys and commands may be used independently, with or without any other keys. Also, any lesser part of the 32-key pattern can be used. Let's look at three such subpatterns, and the full 32-key version.

The simplest keyboard (Fig. 5) uses only 10 keys, those corresponding to the digits from Ø through 9. That pattern would be ideal for security system disarming, with the receiver input mounted behind a window or near a door. Note that the two unused column inputs are left unconnected; since they have internal pull-ups, no external disabling is required.

A somewhat more complex keyboard, the 20-key version (Fig. 6), is probably the best compromise between usefulness and too much complexity. That keyboard adds the following to the 10-key keyboard: OFF, ANALOG UP, ANALOG DOWN, MUTE, two uncommitted toggle-type commands, and four uncommitted continuous-type commands. (We'll talk about the command types in a moment.)

Since all of the available rows and col-

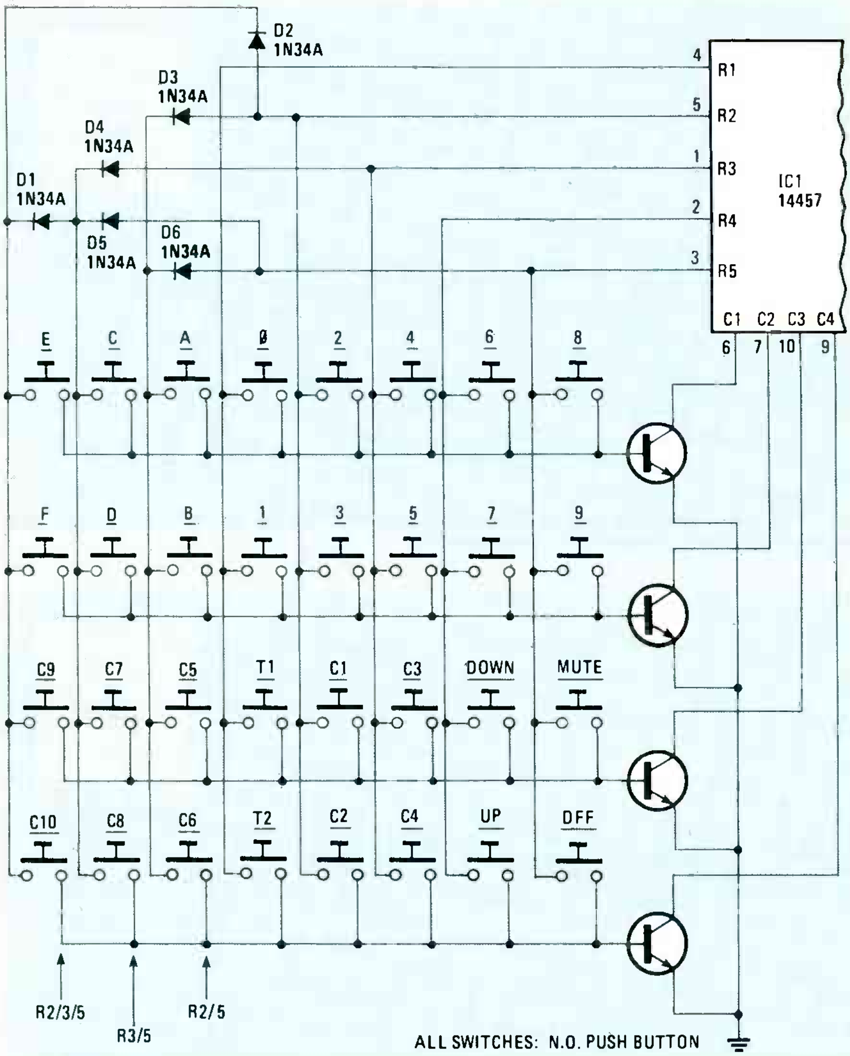


FIG. 7—THE 26/32-KEY keyboard. If the extra commands are not needed, switches C5–C10 can be deleted.

umns are used for the 20-key keyboard, three extra rows must be "synthesized" to access the remaining 12 commands. That is done by using an array of diodes (Fig. 7) to allow each of the new rows to short more than one of the existing rows to ground at the same time. The three new rows are labelled 2/5, 3/5, and 2/3/5, indicating the existing rows used to synthesize each.

If all 32 keys made accessible by adding those synthesized rows are used, six more continuous-type commands are available, along with the six hexadecimal digits A through F. If only access to the hex digits is desired, the six command keys can be deleted, leaving the 26-key keyboard. The only thing that determines whether BCD or hex data can be transmitted is whether or not the hex digit keys are available. If the 10- or 20-key keyboard is used, only BCD data may be sent; with the 26- and 32-key versions, either BCD or hex data can be transmitted.

The receiver

The receiver half of the remote-control system is slightly more complex. The 14458 requires a power supply between 5 and 6 volts, and thus can use a TTL power supply if one is available. If a voltage in that range is not available from the device being controlled, a higher voltage can be regulated down or a separate power supply added. Since the 14458 and it's outboard circuitry are CMOS, not more than 20–30 mA of supply current should be required.

The 14458 has three inputs, one for the incoming signal (DATA IN), one for the oscillator frequency (OSC IN), and one used for automatic power-on reset (POR). The POR input, pin 3, has an internal pull-up resistor and needs only a 0.22–0.47 μF capacitor between it and ground for operation. With such a capacitor in place, when power is applied to the 14458 all of its outputs and internal registers will be reset to 0.

The oscillator used in the 14458 (Fig. 8) is almost identical to that used in the transmitter, except that the receiver requires an external active element, a 4069UB inverter (the active element is internal on the 14457). The ceramic resonator used in the 14458's oscillator must be identical to that used in the transmitter.

The FSK signal is received, as described earlier, by either a photodiode or an ultrasonic transducer. The transducer can be directly connected to an amp input, but the photodiode requires a pull-up biasing resistor from 22K–220K, with the exact value determined experimentally once

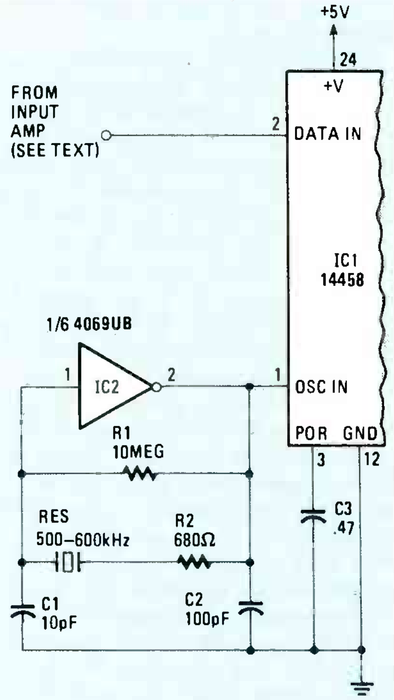


FIG. 8—THE BASIC CONNECTIONS for the receiver oscillator. For single digit operation, pin 9 (M4) would be tied to +5V, and pin 6 (U/V) would be grounded.

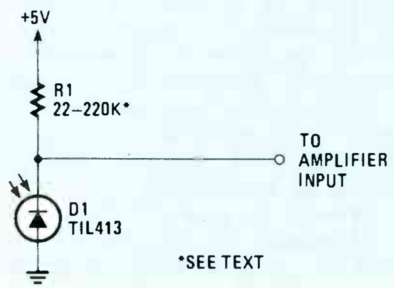
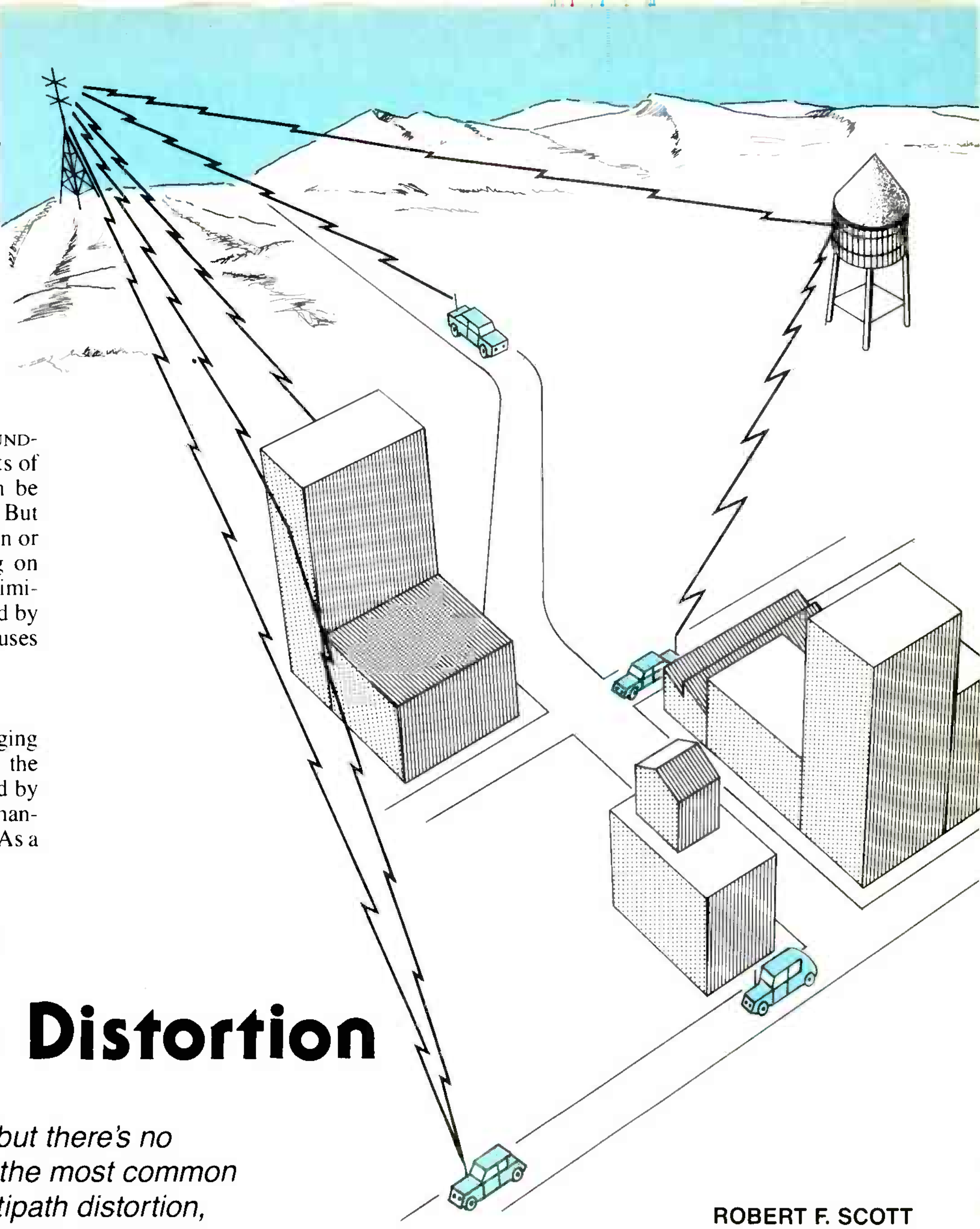


FIG. 9—FOR BEST SENSITIVITY and range, the value of the bias resistor, R1, must be determined experimentally.

the circuit is built (see Fig 9). That bias resistor controls the sensitivity and thus the pickup range of the photodiode. An infrared filter must be used in front of the photodiode to exclude ambient light and further increase its sensitivity. Although a piece of red plastic like that used for display filters can be used, a true IR filter will give better performance.

From the pickup, the signal is sent to an amplifier. We'll show you a suitable amplifier and finish things up. **R-E**



THERE ISN'T MUCH MYSTERY SURROUNDING TV "ghosts." They are the effects of multipath distortion and often can be eliminated without too much trouble. But what of FM "ghosts?" That distortion or "flutter" that you've been blaming on your receiver's tuner, AGC, or discriminator circuits may very well be caused by the same multipath reception that causes TV ghosts.

What is multipath reception?

VHF and UHF signals, those ranging from around 50 MHz to well up in the microwave region, are easily reflected by buildings, water towers, and other manmade objects, as well as by hills, etc. As a

All About Multipath Distortion

FM distortion is annoying, but there's no need to put up with one of the most common types. Here's a look at multipath distortion, and how surprisingly easy it is to get rid of.

ROBERT F. SCOTT

result, at any particular location, an FM antenna may be receiving a signal on a direct, line-of-sight path, as well as via a number of reflected paths. (See Fig. 1.)

That can be an advantage in certain cases. For example, some receiving locations may be in a "shadow" area where, due to intervening buildings, hills, or heavily wooded areas, line-of-sight reception of signals is not possible. In those areas adequate reception might be possible *only* via reflected signals.

Unfortunately, not all multipath reflections are advantageous. Let's take a look at Fig. 1. That figure shows several FM receiving sites, labeled A, B, C, and D, all located about 38 miles from the transmitter. Location A receives signals over two paths. One is a 38-mile direct line-of-sight path. The other is more roundabout—40 miles to the water tower, and then 5 miles to the receiving antenna.

Radio waves travel 186,000 miles per second (0.186 mile per microsecond) or 1 mile in 5.376 µs. The multipath route is 7 miles longer than the direct path, so the reflected signal is delayed 37.63 µs (7 × 5.376 = 37.63). Though not shown, note that some of the signal reflected from the water tower also is reflected downward toward the earth. It then is reflected off the earth to the receiving antenna, forming yet another, slightly longer path. In a moment we'll see how those delays distort the received signal, but first, let's look at the other sites in Fig. 1.

Location B is a good place to receive an adequate direct signal, free from multipath interference. Locations C and D are in the "shadow" of a tall office building and cannot receive a satisfactory direct signal. The FM listener at location D has solved the problem by aiming his antenna at the water tank.

FM signal basics

When an FM transmitter is modulated, its output signal varies above and below the carrier center-frequency at a rate equal to the modulating frequency. The greater the amplitude of the modulating signal is, the greater will be the swing in carrier frequency from its assigned center frequency.

The FCC has defined ± 75 kHz (a total swing of 150 kHz) as 100% modulation, ± 60 kHz as 80% modulation, ± 45 kHz as 60% modulation, and ± 37.5 kHz as 50% modulation.

As long as the percentage of modulation is held constant, the frequency swing remains constant, regardless of the modulating frequency.

Figures 2 and 3 show the "anatomy" of an FM signal. Looking first at Fig. 2, as the modulating signal rises from zero to its maximum at 90 degrees, the carrier

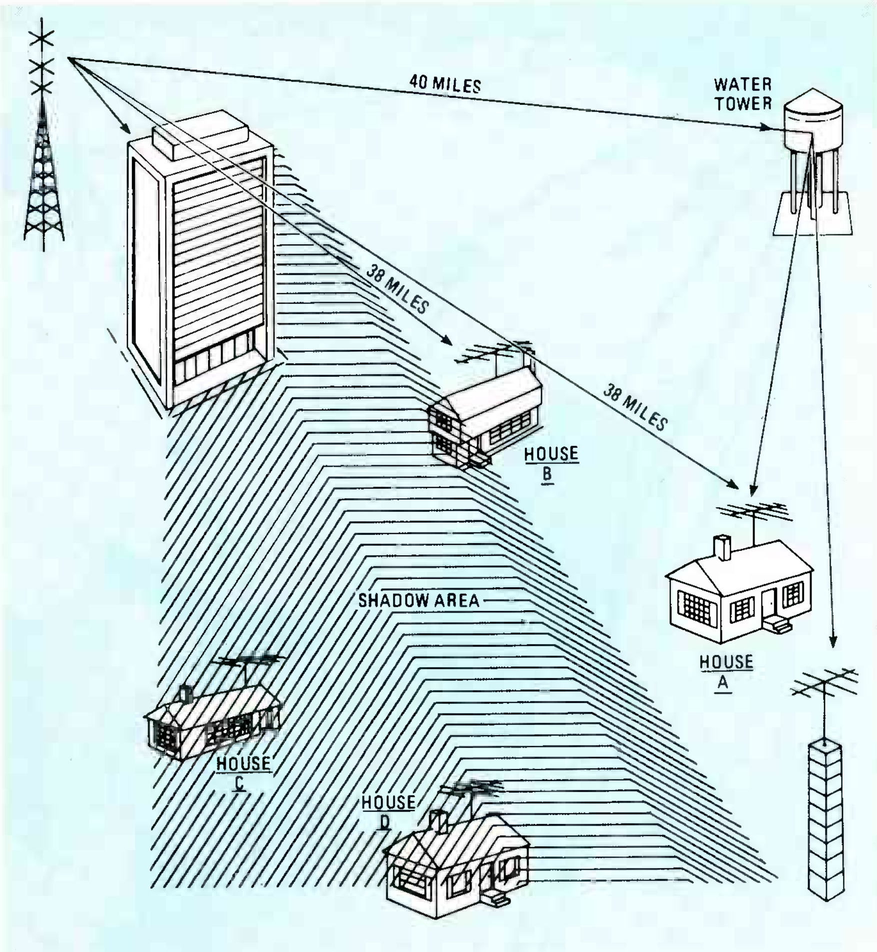


FIG. 1—SOME LOCATIONS RECEIVE direct signals, reflected signals, or a combination of both. In locations where both direct and reflected signals are received, multipath distortion can occur.

frequency swings from its resting (unmodulated) center frequency to a maximum determined by the percentage of modulation.

As the modulating signal passes 90 degrees, the carrier frequency decreases until it returns to the center frequency when the modulating carrier reaches 180 degrees. As the modulating signal swings in the negative direction, the carrier swings from its center frequency toward its minimum (once again determined by the percentage of modulation). Once the modulating signal passes 270 degrees, the carrier frequency begins to rise until it is once again at the center frequency at 360 degrees (0 degrees).

Figure 3 shows the effects of the modulating signal on a carrier signal. Figure 3-*a* is the modulating audio signal, while Fig. 3-*b* shows the corresponding effect on the carrier frequency. Figure 3-*c* shows the modulating signal superimposed on the carrier. In those illustrations the modulation polarity and its relationship to carrier frequency is such that a positive-going modulating signal causes the carrier frequency to increase while a negative swing in modulating voltage cause the carrier frequency to decrease. That polarity relationship is not mandated by FCC regulations or by FM transmitter design.

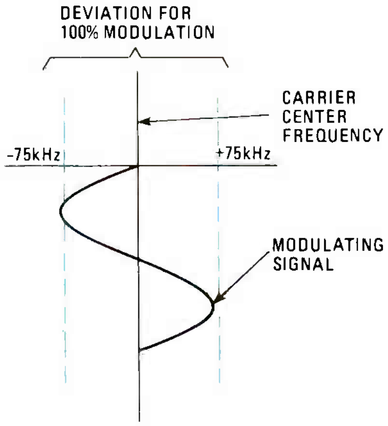


FIG. 2—FOR 100% MODULATION, the carrier frequency will swing ±75 kHz.

An FM transmitter can just as easily be operated with negative polarity where a positive-going modulating wave causes the carrier frequency to decrease.

Causes of multipath distortion

We have seen how a reflected signal takes a longer path and is delayed in reaching the receiving antenna. The chart in Fig. 4 can be used to compare typical delays with differences in the lengths of the direct and reflected paths.

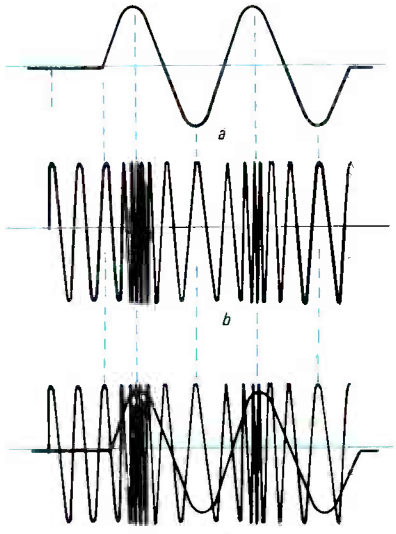


FIG. 3—ANATOMY OF AN FM SIGNAL. The modulating signal is shown in *a*, and its effect on the carrier frequency is shown in *b*. The two signals are shown superimposed in *c*.

When an FM signal is reflected, it usually undergoes a 180-degree phase reversal. So, when the reflected path is a whole number of wavelengths longer than the direct path, the signals at the antenna are out-of-phase; and the strength of the signal at the receiver depends on the relative strengths of the two signals. Complete cancellation can occur when the signals are 180 degrees out-of-phase and of equal amplitude.

When the difference in path lengths is an odd number of half-wavelengths, the signals are in phase. The result is that the signal strength at the receiver will actually be higher than if only the direct signal were being received.

But, most often the difference in path lengths will be something other than an odd or even multiple of the wavelength. Since the carrier frequency of an FM signal is constantly changing, in those instances there will be constant changes in the instantaneous phase and frequency differences in the direct and multipath signals. Thus, the resultant signal at the receiver will contain both phase-modulated

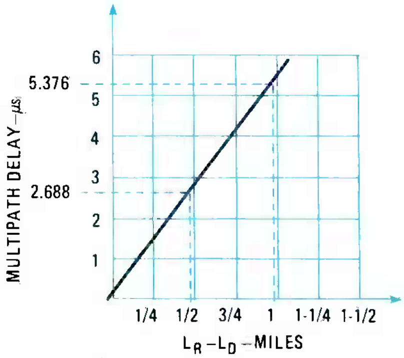


FIG. 4—ONCE YOU'VE DETERMINED the difference in length between the direct path (L_D) and the reflected path (L_R), this chart can be used to find the multipath delay in μs.

and amplitude-modulated distortion components that were not present in the original signal.

Let's take a look at the distortion caused by multipath reception of the FM signal at location A in Fig. 1. The multipath signal travels 7 miles farther than the direct signal, so its arrival is delayed 37.63 µs. Let's assume that, at a given instant, the FM transmitter is 100% modulated by a 5-kHz tone. The period of a 5-kHz sinewave is 200 microseconds. Since, as we've seen, a frequency-modulated carrier reaches its maximum deviation in one direction at the 90-degree point of the modulation cycle, and maximum deviation in the opposite direction at 270 degrees, how much will the carrier swing during the 37.63-µs delay?

Since the period of the signal is 200 µs, we know that at 50 µs, the signal has swung through ¼ of a cycle, or to 90 degrees. That allows us to set up the following proportional relationship:

$$\frac{50 \ \mu S}{90^\circ} = \frac{37.63 \ \mu S}{X}$$

$$50X = 3386.7^\circ$$

$$X = 67.73^\circ$$

To find the percent of modulation at that point:

$$\sin 67.73^\circ = 0.9292$$

$$0.9292 \times 100\% = 92.52\%$$

The carrier swing thus is 92.52% × 75 kHz, or 69 kHz. Thus, when the reflected signal arriving at the receiver passes through the center frequency, the direct signal has advanced 67.73 degrees or 69 kHz.

At that instant the direct and multipath signals interact to produce a 69-kHz beat. That signal is not audible, but it can produce annoying interference as it beats with other components of the composite FM direct and multipath signals.

Similarly, with the same 37.63-µs delay, a 1-kHz tone produces a 17.25-kHz beat, while an 8.75-kHz beat is produced when the FM carrier is modulated by a 500-Hz tone.

It was by chance that we assigned the distances to the direct and reflected paths shown in Fig. 1. Had we assigned values where there was only a half-mile difference, the delay would have been 2.688 µs in the two signal paths. The 5 kHz, 1 kHz, and 500 Hz modulating tones then would have produced beats of 6.3 kHz, 1.26 kHz, and 630 Hz, respectively.

Note that the preceding discussion is based on signals strong enough to modulate the carrier 100% and drive it to full ±75-kHz deviation. If, in the examples above, the carrier is modulated only 50%, maximum deviation is only ±37.5 kHz and the beat interference frequencies would be half of those given above.

The interference frequencies given in the above examples are generated when the modulating signal contains but a single frequency. But typical FM signals contain a variety of frequencies, and the multipath distortion caused by them can be exceedingly complex and constantly changing.

Reducing multipath distortion

Generally, multipath distortion can be reduced to an acceptable level, or completely eliminated, by any method that can be used to insure a 40- to 50-dB difference in the strengths of the direct and reflected signals. Usually, the approach would be the same as that used to eliminate TV ghosts. That is, install a highly directive receiving antenna that has a good front-to-back ratio, a sharp frontal lobe, and a minimum of spurious side and back lobes. An antenna rotator would be used to aim the antenna at an interference-free direct signal—keeping the direct signal well within the main portion of the forward lobe while causing the unwanted reflected signal to fall in a null in the response pattern.

If your FM receiver has a signal-strength meter, you can swing the antenna and measure the angle between the direct and reflected signals. If the multipath signal is arriving from 20–30 degrees right or left of the direct signal, it may be possible to eliminate it by stacking two identical high-gain antennas, one above the other, one-half wavelength apart. In addition to increasing direct-signal pickup by 2.5 to 3 dB, stacking sharpens the forward lobe—possibly enough to completely eliminate multipath interference.

If the reflected signal arrives from the rear of the antenna and is not sufficiently attenuated by conventional vertical stacking (as described above) try stagger stacking, as shown in Fig. 5.

Stagger stacking provides a 10- to 20-dB improvement in the front-to-back ratio, while still providing a substantial increase in forward gain. In stagger stacking, the antennas are spaced 0.67 to 0.7 wavelengths apart vertically, and the upper antenna is spaced one-quarter wavelength ahead of the lower one. The coax line between the upper antenna and the coupler is one-quarter wavelength longer than the coax connected to the lower antenna.

Because of the one-quarter wavelength horizontal stagger between the antennas, the wavefront of the incoming direct signal reaches the upper antenna one-quarter wavelength (90°) before it reaches the bottom one. However, the extra one-quarter wavelength section of coax from the upper antenna delays the signal 90 degrees so it will be in phase with the signal from the bottom antenna when the two combine in the coupler. That provides an added 2.5 to 3 dB gain.

The wavefront of the reflected signal arriving at the rear of the antenna array reaches the upper antenna one-quarter wavelength after it has reached the bottom antenna. The signal at the upper antenna is delayed an additional 90 degrees by the added quarter-wave section of coax downlead. Thus, the reflected signals from the top and bottom antennas arrive at the coupler 180 degrees (one-half wavelength) out-of-phase, so they will cancel. The rejection of the reflected signal is typically −20 dB, and may be −30 dB with careful design and construction.

When designing a stacked antenna array, remember that FM signals travel slower in cable than in free space (or the atmosphere). Because of that, the wavelength of the signal in cable is shorter than

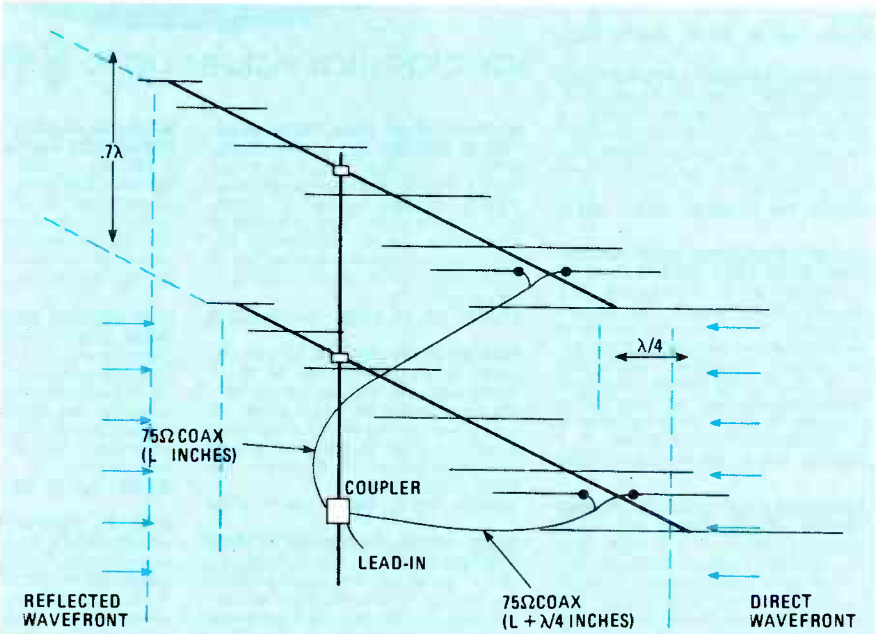


FIG. 5—WITH STAGGER STACKING, the upper antenna is mounted so that its elements are located ¼ wavelength ahead of the corresponding elements of the lower antenna.

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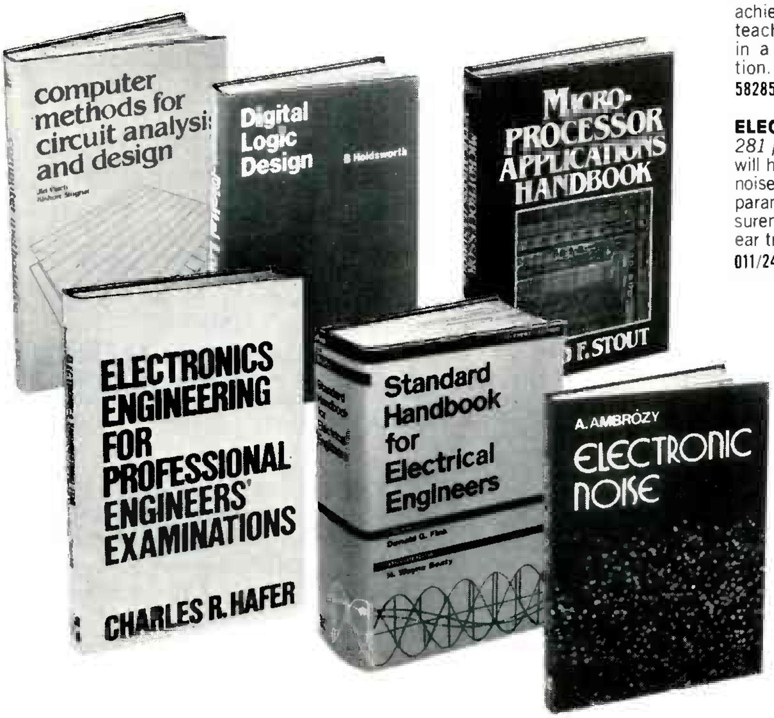

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the wavelength of the signal in free space. Therefore, when calculating the length of a section of transmission line, you must compensate for a characteristic called velocity of propagation. For solid-dielectric coax, the velocity factor is 0.66; the velocity factor is 0.85 for foam-dielectric coax. Thus a piece of solid-dielectric coax that is one wavelength long will be only 66% as long as the wavelength of the signal in free space.

Let's next calculate the dimensions of the array shown in Fig. 5. We'll use 100 MHz, the center frequency of the FM band, as our design frequency. In free-space:

λ = 11,700/f inches
$\lambda/2$ = 5850/f inches
$\lambda/4$ = 2925/f inches

where λ is the wavelength and f is the frequency in MHz. At 100 MHz, one wavelength is 11,700/100, or 117 inches. Vertical spacing between the antennas is 81.9 inches (117 × 0.7) while the horizontal offset or staggered dimension is 2925/100, or 29.25 inches. The solid-dielectric coax connecting the antenna array to the coupler consists of two lengths. The shorter length, which measures L inches, connects the bottom antenna to the coupler. The other section is a quarter wave longer, so it measures L + 19.3 inches (66% × 117/4).

Horizontal stacking

When the reflected signal arrives from an angle to the right or left of the direct signal, two high-gain directional antennas can be stacked horizontally (side-by-side) and aimed for maximum pickup of the direct signal. Their center-to-center spacing can be adjusted to develop a null in the pattern corresponding to the angle of arrival of the reflected signal. Figure 6-*a* shows that at some spacing, H, between the antennas, the reflected signal arrives at an angle corresponding to one of the minor lobes in the pattern. In that situation, multipath distortion will be severe.

To minimize that distortion we can "warp" the response pattern so the reflected signal falls at a null between the major and minor lobes as shown in Fig. 6-*b*. When that occurs, the reflected signal "sees" half-wave or 180° spacing between the two antennas. When that happens, the signal voltages induced in the two antennas are 180° out of phase, so they cancel at the coupler.

On the other hand, the antennas are oriented so that the direct signal reaches both simultaneously. That means that the signals are in phase. The overall result is a 3-dB increase in the strength of the direct signal and the cancellation of the reflected signal.

Success in cancelling the reflected signal depends on how precisely we know the value of θ, the angle between the direct and the reflected signals. When the location of the reflecting surface is not known,

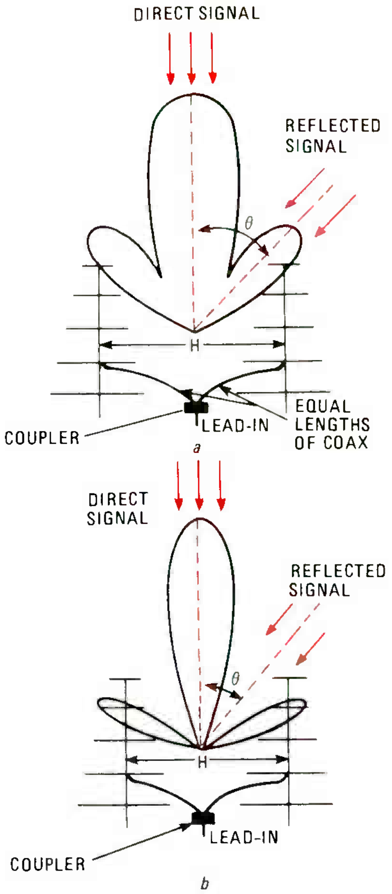

FIG. 6—WITH HORIZONTAL STACKING, at some spacing, H, the reflected signal will arrive at an angle corresponding to one of the antenna system's minor lobes; that is shown in *a*. It is possible to alter the spacing between antennas so that the reflected signal comes in at an angle corresponding to a null between the lobes; that is shown in *b*.

you can measure θ by first orienting the antenna for best reception of the direct signal and then repositioning it for best reception of the reflected signal. The spacing between antennas, H, can be determined from:

$$H = (\lambda/2)\sin\theta$$

where H and λ are in inches.

Let's see how that formula is used to calculate H by looking at an example. Let's assume that the carrier frequency of the incoming signal is 100 MHz, and that the angle θ between the direct and the reflected signals is 40°. First, λ is equal to 11700/100 = 117. Plugging into the equation, H = (117/2)sinθ = (117/2)0.6428 = 117/1.285 = 91.4 inches.

The graph in Fig. 7 shows the relationship between θ and the center-to-center spacing, H, in wavelengths. Note that as θ increases beyond 30 degrees, the spacing is quite small, and the antenna elements may touch or overlap. In such cases, space the antennas an odd multiple of H apart. That allows clearance without changing the response pattern.

Diversity reception

While eliminating multipath distortion for a home receiving setup presents relatively few problems, the same can not be said for car setups. There, the directional signal path between the FM transmitter and the moving car is constantly changing. At times the received signal is severely attenuated or completely blocked, causing fading and "drop out." At other times, the car's antenna picks up signals reflected from the ground, buildings, hills, etc. As the car moves, the phase relationships between the direct and reflected signals are constantly changing, adding and then subtracting at random rates to vary the instantaneous signal strength, producing a multipath distortion

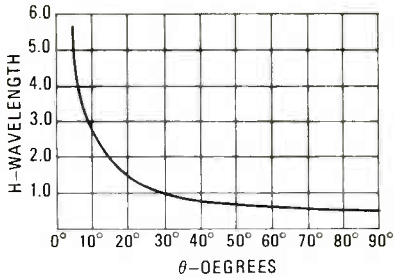

FIG. 7—THIS CHART shows the relationship between the angle θ and the proper spacing in wavelengths between antennas in a horizontally stacked system.

called "flutter" or "picket-fencing."

It was discovered many years ago that signal strength at a particular moment may be quite different at antennas spaced just a few wavelengths apart. A technique to eliminate the above mentioned receiving problems, called diversity reception, takes advantage of that phenomenon by feeding an FM receiver from two antennas. The theory being that as the signal strength is fading on one antenna, it will be constant, or even increasing on the other. A diversity receiver is designed to determine which antenna is providing the strongest signal at a particular moment and to switch to that antenna.

Figure 8 is a block diagram of a diversity receiver. As is shown, such a receiver features two antennas, two tuner front ends, two IF amplifiers, two FM detectors, a common local oscillator, and a comparator. Clarion Corp. of America (5500 Rosecrans, Lawndale, CA 90206) sells a diversity receiver, the Audia *DTX-1000* shown in Fig. 9. In that receiver, a common local oscillator tunes both tuners to precisely the same frequency. The signals in the two IF-amplifier systems are rectified separately to develop signals consisting of a direct-path voltage and a multipath voltage.

Amplitude modulation (AM) and phase modulation (PM) components develop when an out-of-phase multipath signal is combined with the direct signal. The AM components of the multipath sig-

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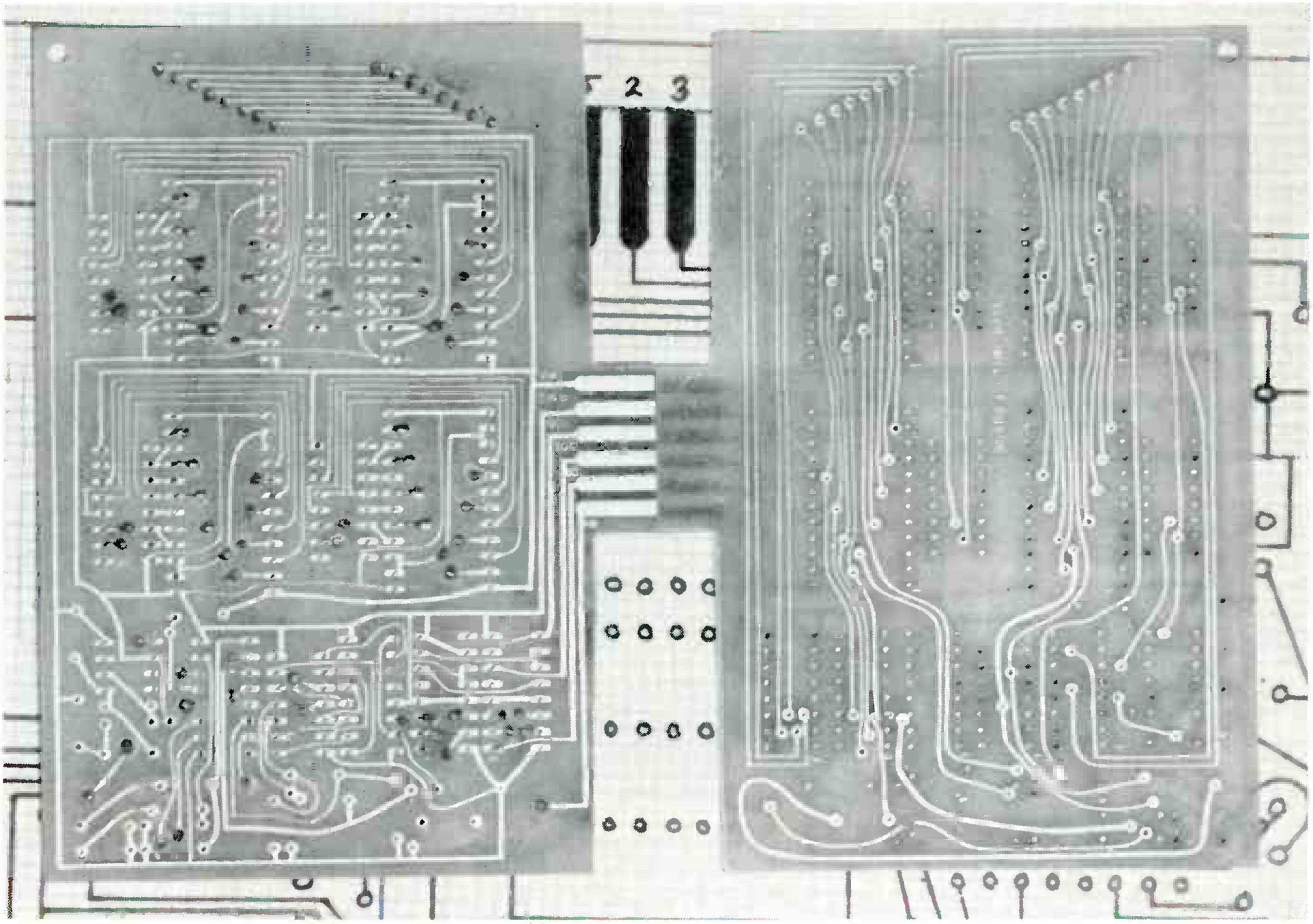


Designing Double-sided PC Boards

Making a double-sided PC board is child's play when designing one. Here are a few hints to ease the design process.

ROBERT GROSSBLATT

Part 2 LAST MONTH WE WERE outlining methods of routing traces on the PC board. Let's finish that discussion and go on to the actual etching process.

We've discovered a few general rules that should be kept in mind when routing traces.

1. You can route a trace through IC pins on the foil side, but doing it on the component side is asking for trouble.
2. Power and ground connections should be made in each section separately. When the whole circuit has been laid out, the individual sections can be joined.
3. Keep all traces except those going between IC pads, at least one tenth of an inch (two divisions on the graph paper) away from the IC pads. That leaves room for solder pads
4. Bus lines that have to be routed to many IC's on the board should be handled as in number 2 above.

If you look at a commercially made board, you'll see that traces are routed through IC pins on both sides of the board. Now, you can lay out your board that way; it's easy to do things like that on paper. But when the time comes to actually make the board, you're going to regret it. If your registration or drilling is even the slightest bit off, you're going to be swamped with shorts and broken traces. And if you use IC sockets, (and you should!), the traces most likely to be causing the problem will be hidden under the wall of the socket.

After you get the IC's drawn in, connect the power, ground, and whatever other pins have to be joined. Once you've done that, start drawing in the other components that are part of this section of the circuit. Don't forget to draw the pads and outlines of the components on the top side of the board. Put in the traces you need to connect everything together, making sure you leave an escape path for the traces that have to go somewhere else on the board.

Getting traces from one side of the board to the other is a major problem with home-made double-sided boards. Commercially made boards use plated-through holes, but we've never found a reliable way to make plated-through holes at home. The best way is to "fake it" by using a component leg as a feedthrough. By drawing solder pads in register on both sides of the board, you can easily get a trace to the other side of the board. The real problem comes with traces that connect only to IC's.

There are a couple of options to handle that type of situation. Which one you choose depends on your circuit, your patience, and your concern with the final appearance of the board.

- Drill slightly larger holes that can fit a small wire as well as the IC leg and solder the wire to the pads on both sides of the board.
- Use wirewrap sockets and leave them sitting a quarter of an inch or so above the component side of the board so you can solder to the pad on the component side.
- Use Molex pins instead of IC sockets.
- Draw in solder pads for small pieces of wire used only for connecting the two sides of the board.
- Don't use sockets and solder directly to the IC legs.

Not all those choices are practical. Not using sockets is ridiculuous and drilling larger holes can be dangerous. The other three options depend on how you want the final board to look, and what plans you have for producing the board. If you're going to have the board commercially made, using wire-wrap sockets or Molex pins is good because the holes can be plated through by the people that make the board. If your board will only be made at home, you can draw in solder pads for through-the-board jumpers. The design of the board is slightly more complicated when you use that method, and assembly is a bit more work. But the advantages are that it can be done at home and the holes can be plated through later on.

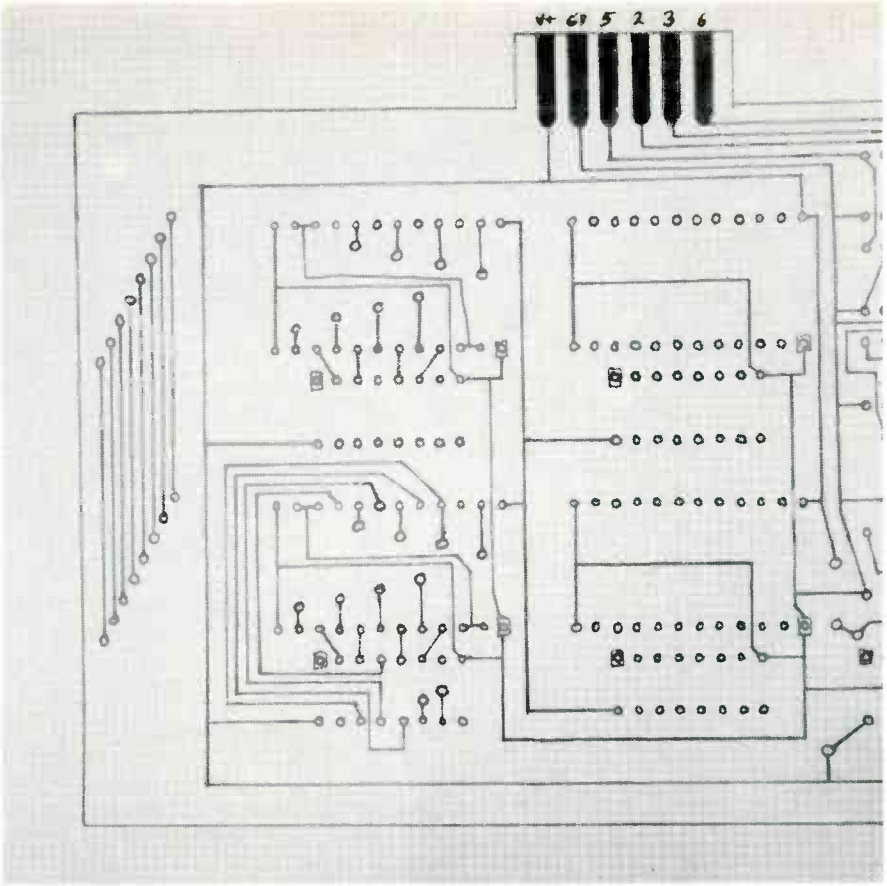


FIG. 6—FOIL PATTERN LAYOUT for the pairs of 4508's and 4040's.

Figure 5 shows the layout with the first section of the circuit drawn in. You can see that extra pads were used for the feedthroughs needed to get some connections to other parts of the circuit. As you're doing the layout for your own board, it's a good practice to always end the I/O of each section in a place with room enough for feedthrough solder pads. That's true even if you decide to use some other method of jumping them to the other side of the board. No matter what kind of PC design you're doing, always keep in mind that lost options are potential problems. In other words, until the final layout is done, don't eliminate any possibilities.

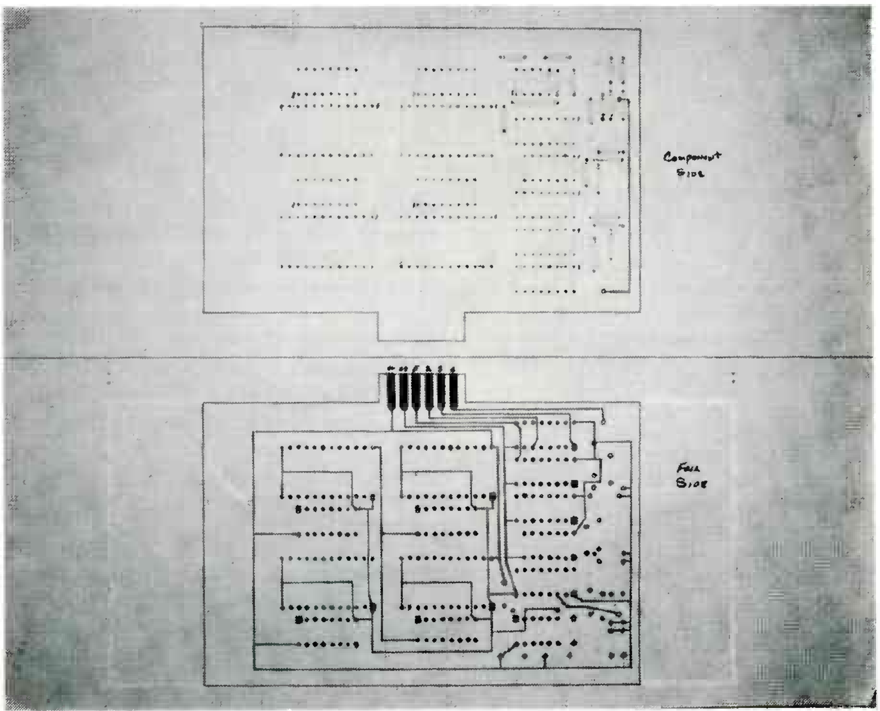


FIG. 5—THE I/O CONNECTIONS should be made first, as we have done here.

As you can see from the block diagram and schematic of our circuit, there is one large section made up of four identical pairs of IC's. (Each pair is made up of a 4508 and a 4040.) Since each of those pairs is connected in the same way, doing the layout for one means we've done the layout for all of them. In Fig. 6, the PC pattern for those parts has been drawn in. Most of the I/O has been brought over to the component side because the foil side got jammed up with the traces connecting the IC's together. Now that we're talking about traces on the component side, we should tell you how to decide which traces should be on which side of the board.

- Put traces on the component side only when there's absolutely no room on the foil side.
- Horizontal runs should be on one side of the board and vertical runs should be on the other.

If you pay careful attention to the first "rule," you may be lucky enough to find that you can add one or two jumpers and reduce the whole layout to a single-sided board. The importance of the second "rule" becomes evident when you get further into the layout. As you start laying out the traces on the foil side that are needed to connect the components together, there

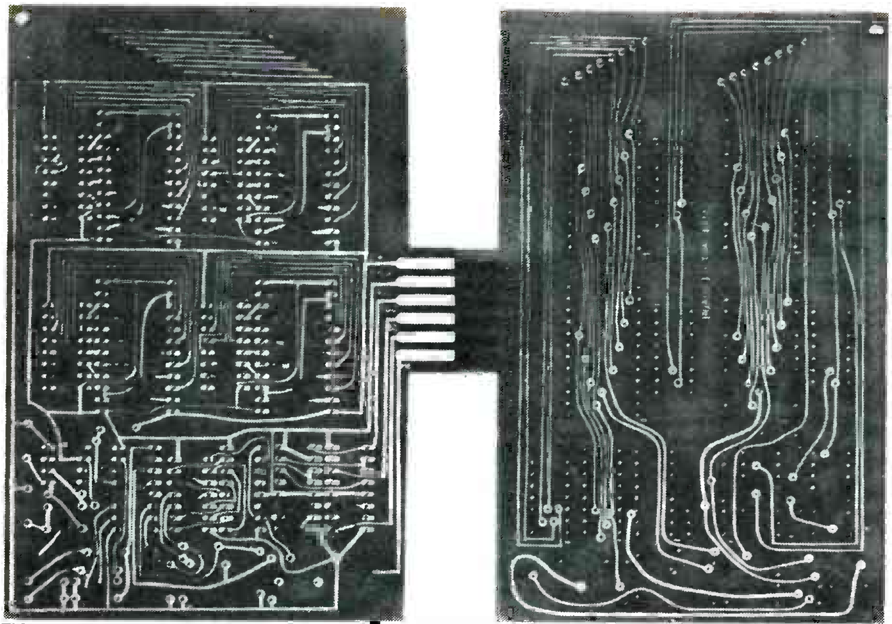


FIG. 7.—THE FINISHED LAYOUT is shown here on an etched board. Note how the traces run between the top and bottom of the board.

will be fewer open paths either vertically or horizontally, depending on your layout. Reserving a board side for each direction makes everything a lot more orderly.

You can see that extra board space was needed just for the I/O traces. That's why you should make the layout for each section as compact as possible. It's impossible to tell at the outset how much extra board space is going to be needed by the layout itself. If you have no restrictions on the size of the board, that's not much of a problem. But if the board has to fit somewhere in particular, you have to be very stingy in allocating board space as your design develops.

The actual procedure for running a continuous trace on both sides of the board is surprisingly easy. Since we 'unfolded' the board, not only are both sides laid out in front of us but both of the layouts are correct left to right. Some other methods of doing double-sided layouts use tracing paper and light boxes and wind up giving you a reversed image of one side of the board. Double-sided layouts are complicated enough without having to work with backwards.

When you want to move a trace to the other side of the board, end the trace with a solder pad and then find the corresponding point on the other side of the board using the graph-paper lines as a guide. Use the dividers to transfer the distance from the baseline, checking it several times to make sure the dividers haven't slipped. Try to keep all the solder pads on the intersections of the graph paper lines; it's easier to keep from making mistakes that way.

As your layout gets near completion, it's not unusual for a trace to make several trips between both sides of the board. Just as traces fill up the foil side, the components themselves will fill up the other side. And since you want to eliminate as many problems as possible, try to keep the traces on the component side of the board as far as you can from the components. That's particularly important with IC's, since the board space next to the holes is going to be permanently covered by the IC sockets.

Figure 7 is the completed board layout. It may seem to be complicated but that's only because it's our layout and not yours. Just as it is with schematics, the circuit is self evident to the person that drew it. By keeping everything in separate sections and building the final layout a section at a time, you can keep all of it straight in your mind. Of course it's always nice to put helpful labels, such as pin and part numbers, on the board. It can't hurt and it could save a lot of head scratching later on.

In Fig. 7, you can see that the power and ground connections have been made and brought out to two of the card-edge fingers. The thing to notice here is that the routing for these traces isn't a straightforward one. They wander over both sides of the board. If we had been connecting each section up as we went along, chances are the layout would have been a lot different looking. Not better, not worse, but only different.

After you've checked the connections against your paperwork and checked the paperwork against the breadboard, the time has come to use drafting aids to blacken the pads, doughnuts, and traces you've drawn in with the blue pencil. Keep things nice and neat and don't worry about the blue lines: standard lithographic film won't see them—all it knows about is black and white. Don't use drafting tape that's less than one sixteenth of an inch wide because it's hard to get a successful etch with a line that's thinner than one thirty second of an inch thick. The traces themselves should be at least 0.2 inch apart for the same reason. If you're working at greater than double size, don't forget to multiply those dimensions accordingly.

Once things are all blacked in, put registration marks on the corners and the artwork is ready to take to your local lithographer. He can reduce your layout to the right size and make the necessary negatives or positives for you on lithographic film.

Now we get to the easiest part of the entire task, etching the printed-circuit board itself. Although that is a completely different topic from the one we've been dealing with in this article, we've assumed that you are familiar with the technique and have not covered it here. If that is not the case, you can learn about the etching process in "Etch Your Own PC Boards, a two part article that appeared in the January and February 1983 issues of **Radio-Electronics.**

Details, details!

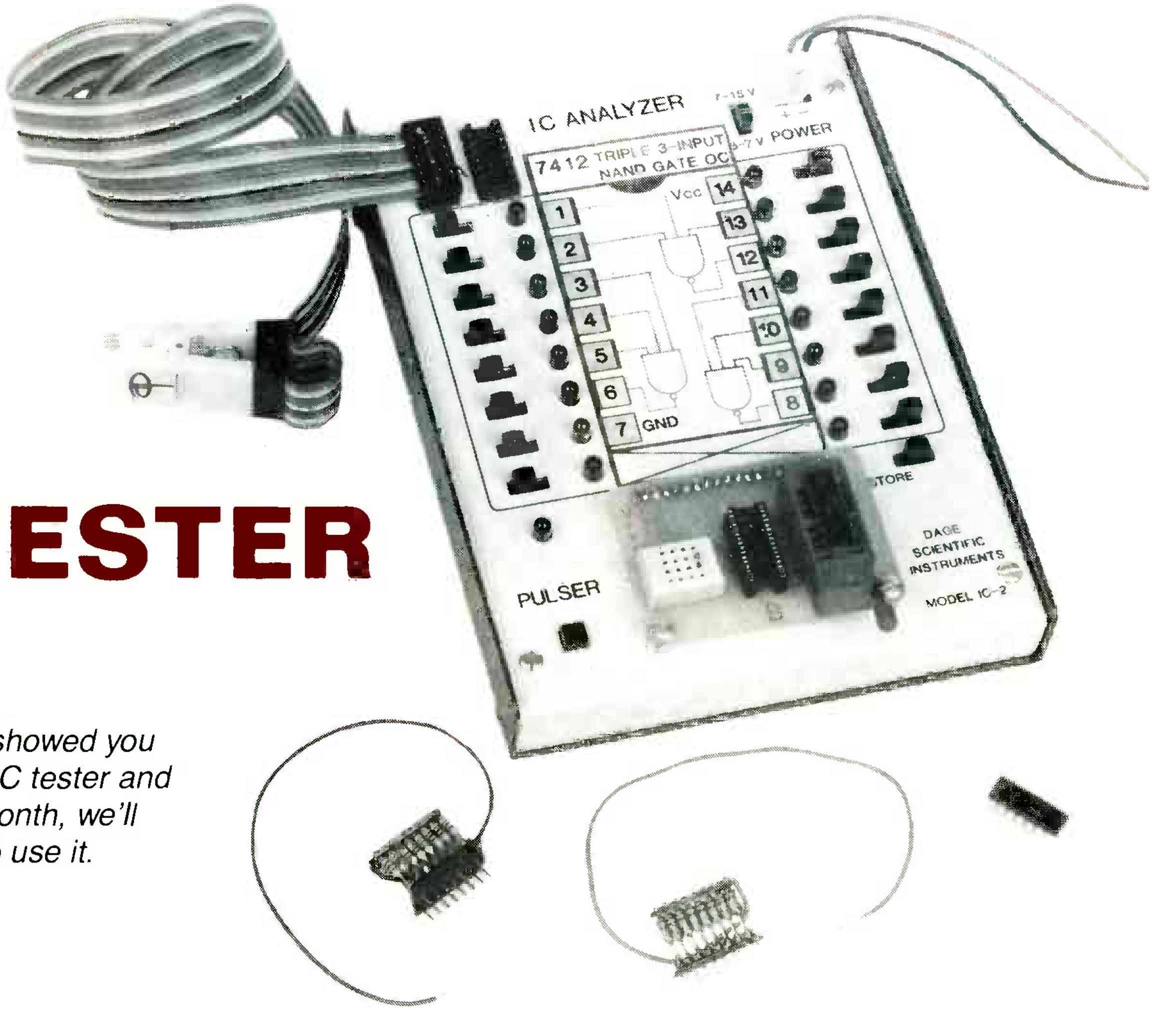
One thing that hasn't been mentioned so far is that the secret ingredient to something as complex as a double-sided PC layout is an overwhelming attention to detail.

As your layout starts to unfold on paper, it gets easier and easier to make a mistake. An incorrectly transferred measurement, a wrong trace, IC's drawn in backward, etc. can be disastrous. *Be careful, and keep good notes!* By the time you finish

ONCE THE LAYOUT IS FINISHED, it's time to etch the board using chemicals and aids like the ones shown here.

the layout for the last section on the board, it's easy to forget what goes where in the first one.

Laying out a double-sided PC layout is much easier than you think it is. But like a lot of other things, the only way to learn how to do it is to do it. Start with a simple one, preferably a circuit for which you've already done a single-sided layout. The double-sided layout will make the board smaller and more compact. (The layout we've been using as an example stuffed 14 IC's and a bunch of other components onto a 3×5-inch board.) And though compactness might not be your goal, remember that you can always make a board bigger, but it's sometimes hard to to make it smaller. **R-E**



IC TESTER

DAVID H. DAGE

Last month, we showed you how to build an IC tester and analyzer. This month, we'll show you how to use it.

Part 2

WHEN WE LEFT OFF last month, we had put the IC analyzer or tester together and had just finished checking its various functions. This month, we'll show you how to put the tester to work. Before we get started, we should mention that the foil pattern for the solder side of the main board was not shown in the "PC Service" section because of space restrictions. It does, however, appear this month. (See page 83)

IC pinout cards

When using the IC analyzer as a monitor or tester, you must know how the IC is supposed to function, i.e., how the input pins affect the output pins. The IC pinout cards supply that information.

While the pinout cards cannot supply all the information that you would expect to find on data sheets, they can come surprisingly close. For example, see Fig. 12-*a*, which shows the pinout card for a 7400 quad NAND gate. To use the IC tester in its comparator mode, set each switch either IN (for an input) or OUT (for an output). Setting up the analyzer can be done quickly and easily if each pin on the card is marked appropriately.

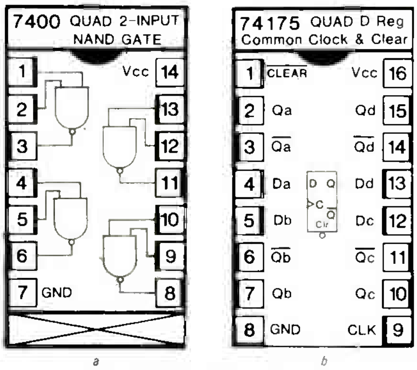


FIG. 12—THE PINOUT CARDS should contain as much information as possible.

A set of pinout cards for the 74xx series of ICs is available from the source mentioned in the Parts List. If you make up your own set, you'll want to include on the cards an easy way to distinguish between inputs and outputs. Our convention is to mark inputs with a bold line toward the inside of the card, and outputs with a bold line toward the edge. You'll also want to indicate which inputs and outputs are numerically weighted, etc.

To monitor and check an IC, we need to know how its inputs affect its outputs. For the most part, that information will be obtained from reading the IC cards, and using a little prior knowledge. The 7400 card is an example of simple gates shown in symbols. Prior knowledge of gate operation is necessary in order to know that when pins 1 and 2 are high, the output at pin 3 will be low.

As another example, look at the 74175 quad D flip-flop with common clock and clear shown in Fig. 12-*b*. You may already know that a D-type flip-flop stores the data on its D input when clocked and that it may be preset (set) or cleared (reset). The data stored is available at the Q output, and it's complement is available at the $\overline{Q}$ output. The 74175 flip-flop can be cleared, but no preset is available. To clear the flip-flop, a low level signal is required (as indicated by the tiny circle). The flip-flop is clocked with a rising edge.

The title "quad D flip-flop with common clock and clear" indicates that there are four separate flip-flops that are clocked and cleared together. The four inputs, the four true outputs, and the four complimented outputs are designated with subscripts a, b, c, and d.

Putting all that together in words and using the pin designations on the card we have: data on pins 4, 5, 12, and 13 will be stored when pin 9 (clock) goes high providing pin 1 is high and remains high. This data will be present on pins 2, 7, 10, 15 and its compliment on pins 3, 6, 11, 14 respectively. After pin 1 goes low, outputs on pins 2, 7, 10, and 15 will go low and pins 3, 6, 11 and 14 will go high.

Using the analyzer

The IC analyzer requires an external source of between 5 and 15 volts DC. It draws approximately 300 mA with all LED's lit. If possible, you should power the analyzer from the circuit under test. For safety's sake, first connect the power cable to the circuit, and then measure the voltage magnitude and polarity at the cable connector. Place the power switch to the proper range, and only then connect the cable to the analyzer.

If the external circuit cannot supply the 300 mA needed, you'll have to use a separate power source. If you do that, *it is important that the two supplies have a common ground (or that the individual grounds remain within 1/2 volt of each other).*

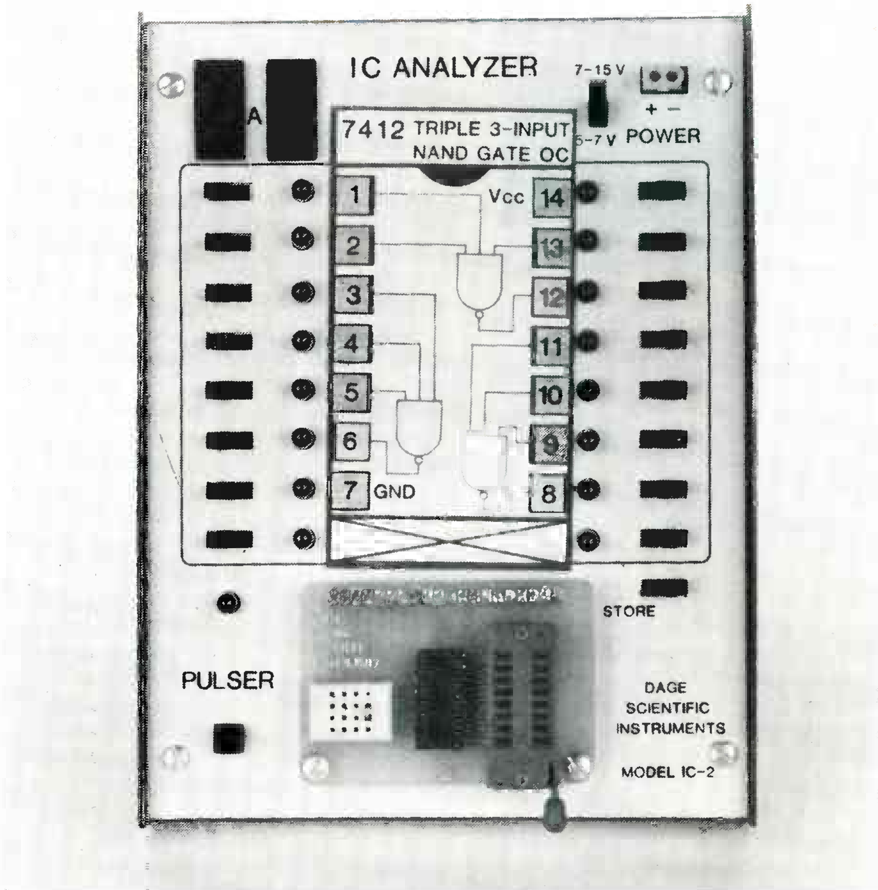


FIG. 13—WHEN THE PINOUT CARD is mounted on the front panel, the function of each switch becomes apparent. And since each IC has its own card, no numbering confusion exists between 14 and 16 pin IC's.

The pinout card corresponding to the IC under test should be inserted in the analyzer, and all switches should be initially in the OUT position, as shown in Fig. 13. However, if you're testing 14-pin IC's, you may want to switch the two bottom (unused) switches to the IN position so that the LED's will stay off and won't be distracting.

The DISPLAY STORE switch should also be left in the OUT (not stored) position until needed. When installing IC's or the DIP clip, always orient pin 1 correctly. Pin 1 is always at the top left—even when installing 14 pin devices.

Be aware of the voltages present on an in-circuit IC before connecting the DIP clip. Many IC's operate as input or output buffers and their pins may not be at logic voltage levels. Any IC with open-collector outputs should be suspect. Remember to orient the DIP clip to pin one.

Using the pulse stretcher

Connection to the pulse stretcher is made at the second row of SO3, the solderless breadboard. Any transition from high to low (or low to high) greater than 20 ns will cause the pulse-stretcher LED to blink on for about 50 ms. Rapid pulse activity below 50 MHz will cause the LED to blink continually. Connecting the pulse stretcher to an in-circuit IC is usually made by connecting the IC to one of the A sockets (using the DIP clip) and connecting the pulse stretcher input from socket B to socket A using an 8-inch length of 24-gauge solid wire stripped at both ends.

The pulser

The pulser or pulse generator is accessed at the third row of the solderless connector, SO3, and it can be connected to an in-circuit IC in the same manner as described for the pulse stretcher. The pulse generator senses the external logic level, and when the PULSER pushbutton (S19) is pressed, it will drive the circuit to the opposite state. If S19 is held closed for more than 2 seconds, the generator will deliver a 100-pps pulse train as shown in the oscilloscope photograph of Fig. 14.

Let's see how we would use the pulse generator to troubleshoot the circuit shown in Fig. 15. Suppose we want to verify that the AND gate IC1-a is operating properly, and suppose that an initial check shows that pin 2 is high and pin 1 is low. In order to see if the gate is operating correctly, we have to override the low level output from IC1-c. The pulse generator output is connected to pin 1 of IC1-a and is activated. If the circuit is operating properly, pin 3 should change state. If it doesn't, both pin 1 and pin 3 must be monitored.

If pin 1 is shorted to ground (and therefore cannot be pulsed), monitoring pin 3 is useless. So let's assume at this point that pin 1 did go high when pulsed, but pin 3 stayed low. One of the internal components of the gate could be faulty, holding pin 3 low. Let's label this a "logic short," which is typically several ohms. Pin 3, on the other hand, could be shorted externally by a solder bridge or an unetched PC trace. Let's label this kind of a short as a "hard short," which is typically less than an ohm.

The pulser can change the level of a logic short but not of a hard short. If you verify that pin 1 pulsed high but pin 3 did

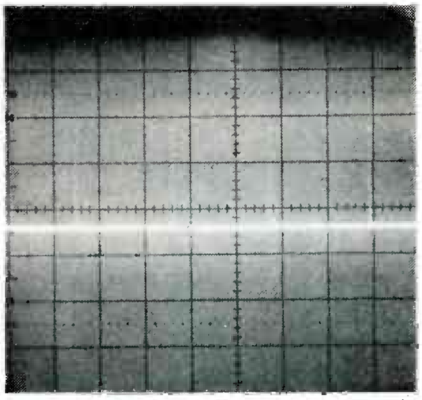


FIG. 14—THE PULSER OUTPUT is shown on this oscilloscope photograph. (Courtesy Tektronix.)

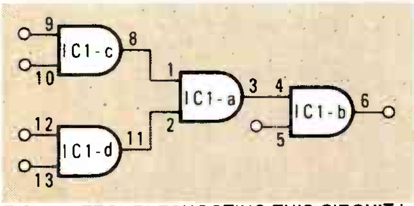


FIG. 15—TROUBLESHOOTING THIS CIRCUIT is easy using the IC tester.

not, the pulser should then be connected to pin 3 and pulsed. If pin 3 can't be pulsed with the pulse generator, look for an external short first before replacing gate A. By using the pulse generator in this manner it is possible to distinguish between logic shorts and hard-wire shorts.

While hard shorts can occur in IC devices, they are not as common as logic shorts. To complicate matters, shorts may exist between inputs (pin 1 and 2), between outputs, outputs to inputs, and circuits shown here to circuits on the other side of a schematic. When using the pulse generator along with the monitor, observe any input or output that changes.

If both pins 1 and 2 are low, they could be connected together and pulsed. The pulse generator has plenty of power to pulse several inputs at once. By tying pins 1 and 2 together, output pins 8 and 11 are also tied together. Should pin 11 change state, it would be shorted through output pin 8. Diodes can be used to pulse more than one input while maintaining output isolation. Use diodes with a low forward drop, such as germanium or Schottky diodes.

Using the in-circuit monitor

To use the IC analyzer as an in-circuit monitor, it should be set up as follows:

- Connect power from circuit under test (or a separate supply)
- Connect jumper cable to socket "A".
- Connect shorting plug to socket "B" and ground at solderless connector.
- Place all IC switches, including the DISPLAY STORE switch, to the OUT position.

Select the appropriate IC card, insert it into the IC analyzer, and connect the DIP clip to the in-circuit IC. If an LED is off, then the corresponding pin is at a low logic level. If the LED is on, then the pin is either at a high logic level or it is pulsing rapidly. A blinking LED indicates slow pulse activity.

The A sockets (SO1 or SO2) are directly connected to the IC under test. Voltage measurements can be made at that point with an oscilloscope or voltmeter. The built-in pulse generator and pulse stretcher can also be connected there.

When an LED is on, its meaning is ambiguous—it can mean that the pin is at a steady state or that it is pulsing rapidly. However, you can determine which state it's really in by using the pulse stretcher.

To determine pulse activity, the built in pulser detector could be connected to one pin at a time at socket "A". That's the recommended procedure when tracing logic or using the pulser. However a much faster method is available. With the shorting plug grounded, the LED will be on if the logic voltage is high or rapid pulse activity is present. If you lift the shorting plug's ground and the LED remains on, rapid pulse activity is present. If the LED goes off, the voltage level is high with no pulse activity. Lifting the ground on the shorting plug to observe pulse activity can be accomplished very quickly. The monitor circuit alone is capable of detecting single pulses greater than 1 μs. They are stored in a flip-flop until reset by the internal 100-pps generator.

If you remove the shorting plug from ground, the LED's will display the complement logic, i.e. on for low, off for high. That is useful when observing complemented inputs or outputs. As an example, the 7447 decoder that is driving a 7 segment display will have active low output when displaying a segment. By using the compliment a lighted LED will correspond to a display segment that is on.

Pull-up plugs

For TTL devices, a floating input is considered to be high. However, depending on internal leakage, its voltage could fall into the undefined area of 1.7 volts or so. Since many designers choose to leave unused TTL inputs floating, incorrect monitoring may result.

That problem can be eliminated by using the pull up plug. Insert it into the A socket and connect its lead to $+V_{CC}$ at the solderless connector.

CMOS devices have very high input impedances, and their inputs must not be left unconnected (floating). A floating CMOS input can, and will, switch from one state to the other. For new designs, that can make troubleshooting difficult.

The pull-up plug can be installed in one of the A sockets and alternately connected from $+V_{CC}$ to ground at the solderless connector. Any input which changes when the pull up plug is changed should be examined more closely. The pull-up plug is not needed for normal CMOS operations, and should be removed from the circuit after checking the inputs.

ORDERING INFORMATION

The following are available from Dage Scientific Instruments, P.O. Box 144, Valley Springs, CA 95252: Plated-thru PC boards, IC pin-out cards and detailed instructions (order number IC-18), $30.00 plus $2,00 shipping. Complete kit of parts less chassis, DIP-clip cable, and sockets (order number IC-20), $79.95 plus $3.00 shipping. Complete kit, includes assembled dip-clip cable, zero insertion force socket, even solder (order number IC-22) $119.00 plus $4.00 shipping. California residents please add sales tax. Countries other than U.S.A. and Canada, please add $8.00

The in-circuit comparator

To use the in-circuit comparator:

- Connect power from the above circuit.
- Connect the jumper cable with DIP clip to socket A.
- Place all switches in the OUT position.

Select the proper card and insert it in the tester. Then connect the DIP clip to the in-circuit IC and install a good IC in socket B. You are then ready to put the switches for ground, power, and the inputs to the IN position.

All the LED's should remain off if the in-circuit IC is operating properly. If an output LED blinks or stays on, something is wrong. If an input LED blinks or stays on, the input is probably floating and should be ignored. To catch and hold single momentary faults, switch S17 to the STORE position. To clear, press S19, the PULSER switch.

Output LED's will go on if an output pin on one IC changes more than 800 ns before the same pin on the other. The old style CMOS outputs called A-Series do not have the drive capabilities that the newer B-Series devices have. It is possible that the A-Series device is driving a large capacitive load and may take longer than 800 ns to switch. The analyzer's good IC is driving practically no load at all and therefore switches very rapidly. Viewing the output on a scope should reveal such timing problems.

For the comparison test to work, both IC's must be synchronized. As an example, assume that a 4060, 14-stage ripple counter is used as a simple divider and that the circuit does not require the divider to be reset or start from zero. To reset this device, pin 12 must be made high. If pin 12 is held low with a resistor, the pulse generator can reset both the in-circuit and the known good IC. They will now run in

continued on page 115

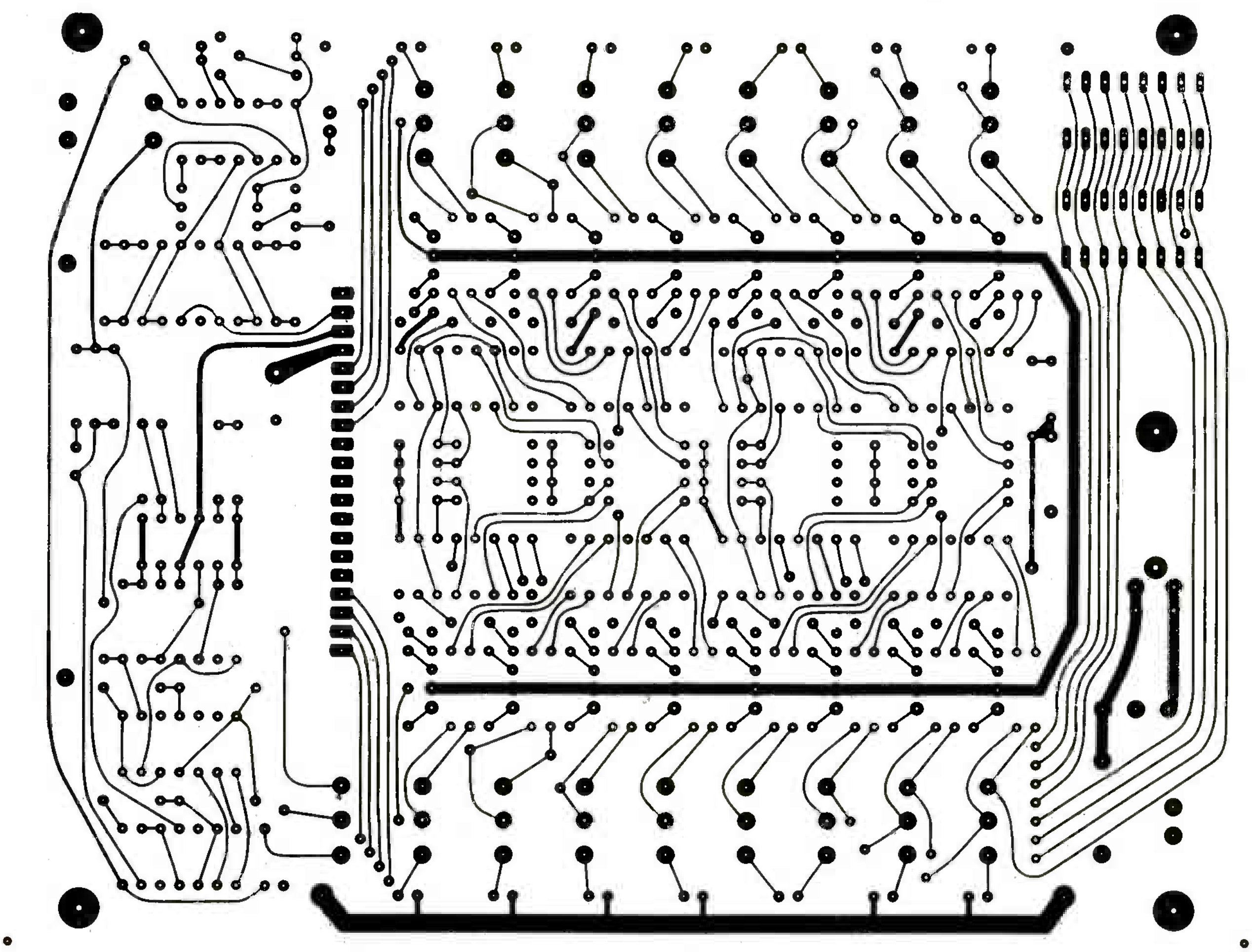
PC SERVICE

One of the most difficult tasks in building any construction project featured in **Radio-Electronics** is making the PC board using just the foil pattern provided with the article. Well, we're doing something about it.

We've moved all the foil patterns to this new section, where they're printed by themselves, full sized, with nothing on the back side of the page. What that means for you is that the printed page can be used directly to produce PC boards!

In order to produce a board directly from the magazine page, remove the page and carefully inspect it under a strong light and/or on a light table. Look for breaks in the traces, bridges between traces, and, in general, all the kinds of things you look for in the final etched board. You can clean up the published artwork the same way you clean up you own artwork. Drafting tape and graphic aids can fix incomplete traces and doughnuts, and you can use a hobby knife to get rid of bridges and dirt.

An optional step, once you're satisfied that the artwork is clean, is to take a little bit of mineral oil and carefully wipe it across the back of the artwork. That helps make the paper transluscent. Don't get any oil on the front side of the paper (the side with the pattern) because you'll contaminate the sensitized surface of the copper blank. After the oil has "dried" a bit—patting with a paper towel will help speed up the process—place the pattern front side down on the sensitized copper



6½ INCHES

THE SOLDER SIDE OF THE IC TESTER BOARD. See page 80 for more information.

PC SERVICE

blank, and make the exposure. You'll probably have to use a longer exposure time than you are used to.

We can't tell you exactly how long an exposure time you will need because we don't know what kind of light source you use. As a starting point, figure that there's a 50 percent increase in exposure time over lithographic film. But you'll have to experiment to find the best method to use with the chemicals you're familiar with. And once you find it, stick with it. Don't forget the "three C's" of making PC boards—care, cleanliness, and consistency.

Finally, we would like to hear how you make out using our method. Write and tell us of your successes, and failures, and what techniques work best for you. Address your letters to:

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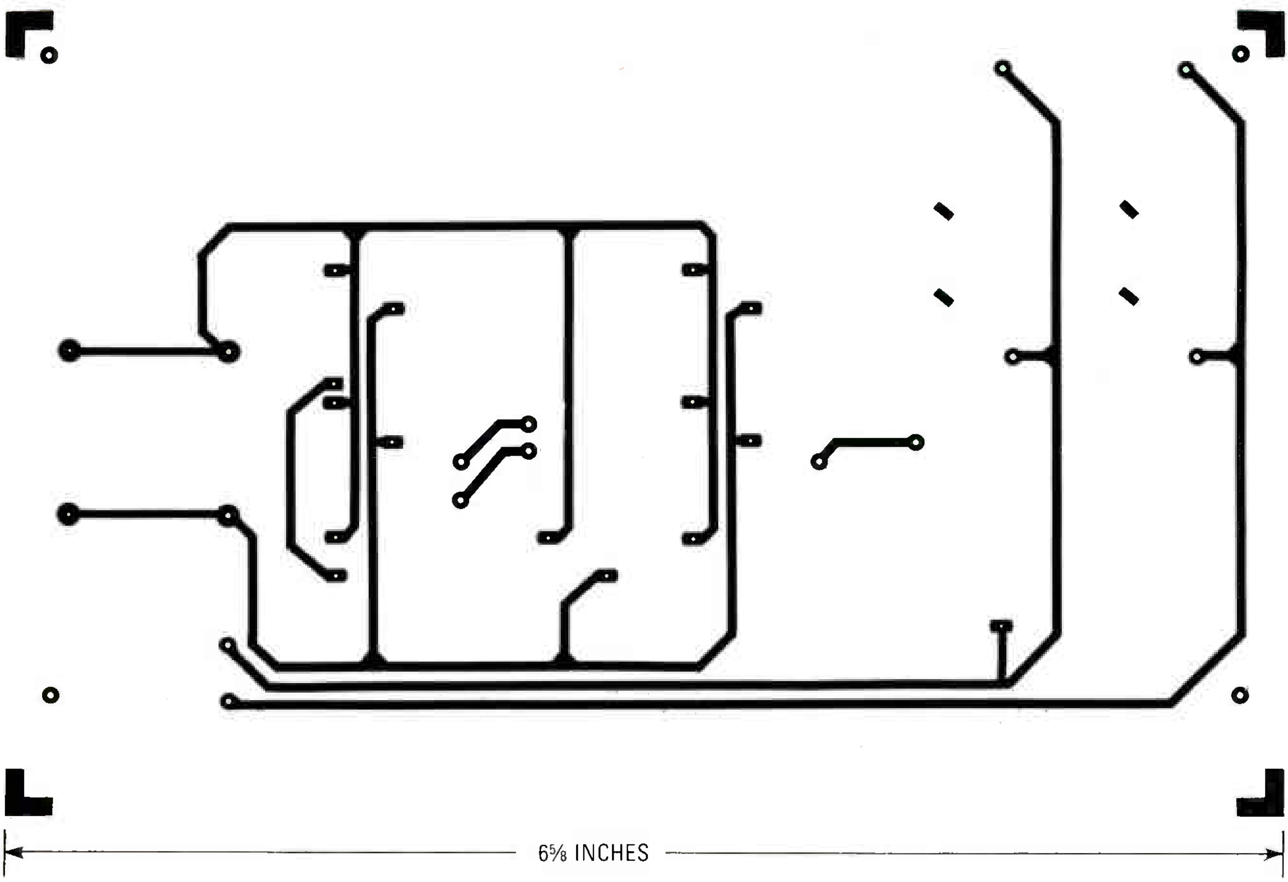
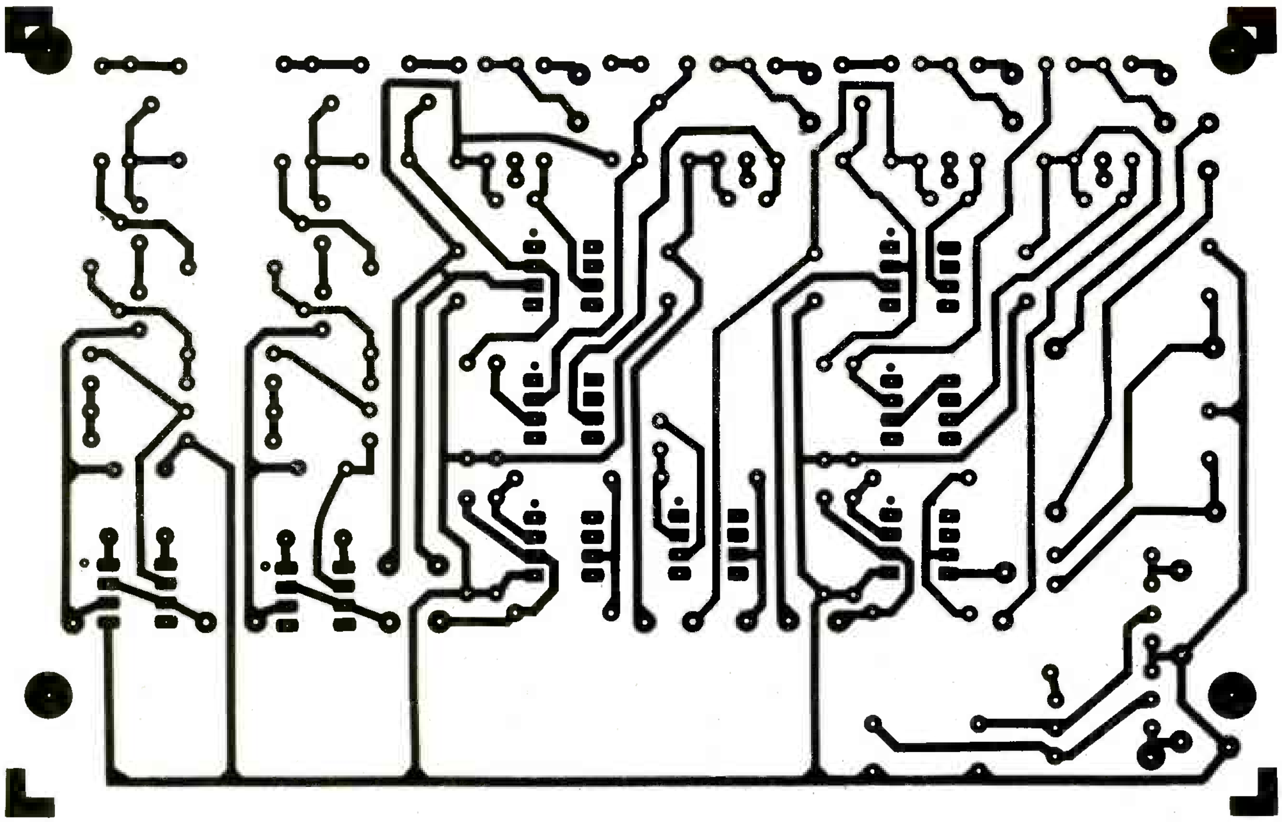
Department PCB
200 Park Avenue South
New York, NY 10003



FOIL PATTERN for the Versatile Power Supply. The component side of the board is shown here.



6⅝ INCHES

SOLDER SIDE of the "Versatile Power Supply" PC board is shown here. For more information on the project, see page 53.

ECG® IC's for Zenith "Z" Chassis

Philips ECG has replacement integrated circuits for the 221-175, -179 and –190 in the Zenith System 3 "Z" chassis. They are the ECG873, 874 and 875. Just three of the hundreds of integrated circuits available from Philips ECG to replace literally thousands of part numbers. All are manufactured to meet OEM specs so you know they fit and they work.

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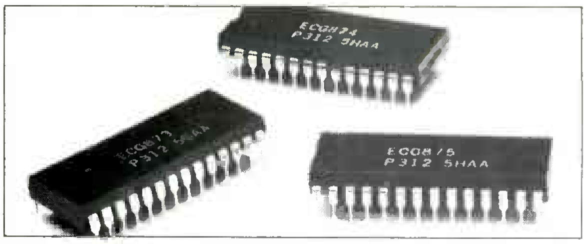

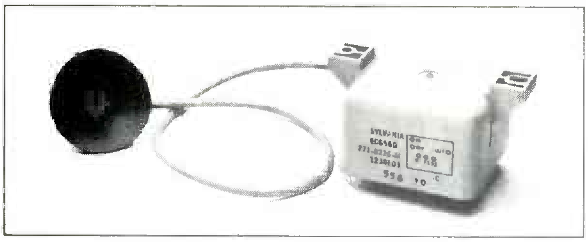

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You have a choice of 29 types of high voltage triplers from Philips ECG, and these 29 triplers replace hundreds of part numbers. Six step, five step, with damper, with resistor—you name it, Philips has it. For example, the ECG559 replaces the Zenith 212-148 and the ECG560 replaces the Zenith 212-147—and only Philips ECG has replacement parts for these Zenith types.

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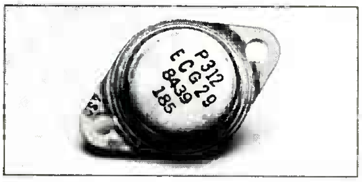

ECG® Bipolar Transistors

Philips ECG replacement leadership is obvious again. The ECG 29, bipolar transistor, used as a replacement in the fan motor control system of Cadillacs, has been added to the Philips ECG line. (The ECG29 replaces Delco part numbers 139DDF and 7391-BT). There are 322 other bipolar transistors in the Philips ECG line that replace thousands of other domestic and foreign transistor types.

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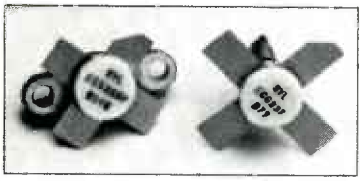

ECG® RF Power Transistors

Philips ECG power transistors are the ideal replacement RF power output devices for fire, police and taxi radios. They are suitable for transmitters and drivers up to 100 Watts RF power. They cover frequencies from the 13 to 30 MHz band to the UHF 806 to 870 MHz band. Most dealers will be happy to learn that Philips ECG replacement RF power transistors are designed to replace units in Asian and European equipment as well as domestic types. So, if it's ECG, it fits and it works... worldwide. Philips offers a selection of over 65 RF transistors that replace literally hundreds of domestic and foreign transistors in a broad range of frequencies.

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ROBOTICS

MARK J. ROBILLARD
ROBOTICS EDITOR

Using a purchased robot in the lab

IN ORDER TO GET STARTED IN ROBOTICS experimentation it is very important to choose the right equipment. Whether you are experimenting with arm-type devices or fully intelligent mobile robots, one of the first decisions you'll have to make is whether to build a robot from scratch, buy a robot kit, or buy a pre-assembled robot. In previous columns I've discussed how to build your own robot out of readily available motors, wheels, and gears. This month we'll discuss the advantages of buying a robot kit, and take a detailed look at one popular kit.

Actually, there are many advantages to purchasing a complete robot kit, rather than building your own from scratch. To begin with, you don't have to go parts-hunting, so you can get right to work. In addition, the mechanical design has already been debugged; the gears fit together and the motors are the correct size. Last, and certainly not least, the electronic controller is debugged, and the operating-system software is usually supplied.

All in all you can save a lot of grief by buying a robot kit. One such kit, called the *Scorpion Mobile Robot*, is shown in Fig. 1. It is manufactured and sold by Rhino Robots, Inc. (3402 N. Mattis, P.O. Box 4010, Champaign, IL 61820).

What is a *Scorpion*?

The *Scorpion* is a two-wheeled intelligent platform you communicate with from a remote computer or terminal. The *Scorpion* has its own built-in computer system. The 6502 microprocessor controlling the motors and sensors is the same as that used in the Apple *II*.

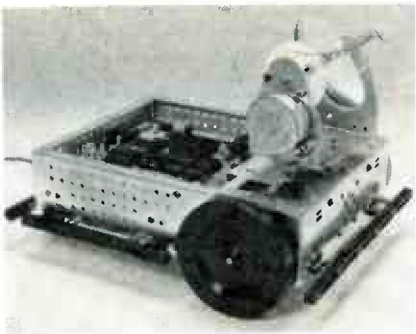


FIG. 1

FIG. 2

An 8K operating system that has been specifically designed for the *Scorpion* is supplied in ROM (*R*ead *O*nly *M*emory). In addition, there is 2K of RAM (*R*andom *A*ccess *M*emory) available for user programs.

The I/O capabilities of the system are quite impressive. There are 32 lines of I/O, and provision has been made for adding even more I/O.

If, after experimenting, you find that you need more RAM for programs, more I/O for controlling external devices, etc., there are two 44-pin bus connectors on the PC-board that allow expansion through user-designed or commercially-available cards.

Communication with *Scorpion* is handled via an RS-232 serial link. Located on the *Scorpion* control board is a programmable UART (*U*niversal *A*synchronous *R*eceiver *T*ransmitter) with a built-in baud rate generator.

The mechanical system of the *Scorpion* is similar to the one used in the two-wheeled platform presented in last month's column. However, Rhino chose stepper, rather than regular, motors to allow more precise control over the robot's motion. A punched aluminum chassis provides support for the two steppers which are connected through gears to the main drive wheels. There are also two idler wheels; they are mounted near the back end of the *Scorpion*, one per side.

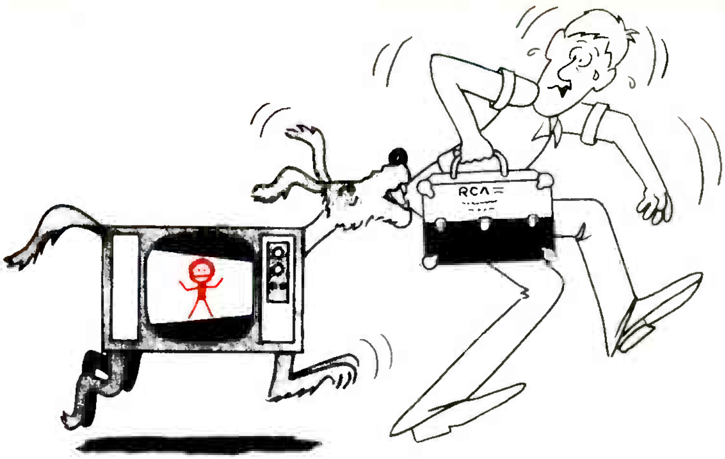
Figure 2 shows the major components of the *Scorpion* kit. What is not shown is the multitude of screws, wires, and other small components that are supplied by Rhino to make the *Scorpion* a complete, stand-alone kit.

There is no power supply included with the *Scorpion*. Because the four stepper motors (two are used to control the robots motion; we'll get to the other two in a moment) draw a great deal of current, and the controller circuit uses power-hungry NMOS devices, you'll need a hefty supply. In fact, the required power is specified to be 12 volts at 5 amps. Sure, you're not always going to need 5 amps, but your power source must be capable of that much current for those times when all four steppers are running at once.

Let's look at those other two steppers. They perform a very interesting function. Looking back at Fig. 1, you'll notice a radar-like antenna mounted on the front of the *Scorpion* chassis. The manufacturer refers to that device as a *scanner*. It is actually a highly sensitive light meter.

The two stepper motors, one lo-

How Many Times Do You Intend To Let "THE SAME DOG" Bite You ?



★ How many times have you worked all day long trying to diagnose the hi-voltage / LV regulator circuit of a set that is in shut down only to eventually find that a **shorted** video, color, vertical, tuner, AGC, or matrix circuit was causing the set to shut down and, to find that the hi-voltage / LV regulator circuit was working flawlessly all the time?

★ How many times have you spent the day looking for a **short** that was causing the set to shut down, only to eventually find that an **open** vertical, video, matrix circuit or, an **open** HV multiplier was to blame?

★ How many times have you worked all day on the same TV set, only to find out that the set's flyback transformer was defective?

★ How many flyback transformers have you replaced only to find that the original flyback was **not** defective?

★ How many horiz output transistors and Sony SG 613 **SCRs** have you destroyed while simply trying to figure out whether the flyback was good or bad?

★ How many times have you been deceived by your flyback "ringer"? Can you even count the number of hours that your "ringer" has caused you to waste?

★ How many times have you condemned a flyback, only to find that a shorted scan derived B+ source was causing the flyback to "appear" as though it were defective?

★ How many hours have you wasted, working on a TV set, only to find that the CRT had a dynamically shorted 2nd anode (to primary element)?

★ How many new sweep transformers have you unknowingly destroyed because a short existed in one of the scan derived B+ sources?

★ How many times have you said to yourself, "I could fix this - - - -thing if I could only get it to fire up long enough to lite the screen? - - - without blowing an output transistor or a fuse."

★ How many additional bench jobs could you have gotten, had you been able to give an accurate, "on the spot" estimate on sets that were either in shut down or, not capable of coming on long enough for you to analyze them?

If you had been using our all new Super Tech HV circuit scanner, you would have had an accurate evaluation concerning all of the above in about one minute, at the push of **just one** single button.

It's true! Push just one test button and our HV circuit scanner will (1) Accurately prove or disprove the flyback, (2) Check for any possible shorts in any circuit that utilizes scan derived B+, (3) Check the scan derived power supplies themselves for shorted diodes and / or electrolytic capacitors, (4) Check for primary B+ collector voltage and, (5) Check the horiz output stage for defects.

Our HV circuit scanner works equally well on sets with integrated or outboard HV multipliers. It will diagnose any brand, any age, solid state TV set including Sony. The only exceptions are sets which use an SCR for trace and, another for retrace (i.e., RCA CTC 40 etc.). Our scanner will not work on these sets.

In plain English, our HV circuit scanner is even easier to operate than a "plain vanilla" voltmeter.

First off, when you're using a scanner, you **do not** remove the flyback in order to check it. In fact, you don't even unhook any of the wires that are connected to the flyback! All you do is:

(1) Remove the set's horiz output device, plug in the scanner's interface plug, then make one single ground connection. That's all you do to hook it up.

(2) If the primary LV supply is functional and, assuming that the emitter circuit of the horiz output stage has continuity, the scanner will tell you that it is ready to "scan" by illuminating the "ready" light, which is the white button on the test / run switch.

(3) Press the spring loaded (test) side of the test / run switch and the scanner will "look" for any type of a **short** that might exist anywhere on the secondary side of the flyback, including the HV multiplier, any circuit that relies on flyback generated B+ and, including the flyback itself (both primary and all secondary windings). It will simultaneously check for a shorted LV regulator device HV multiplier, or an open or "partially" open safety capacitor.

If a short or, an "excessive load" exists on one secondary winding, all other secondary windings will have "normal" output voltage in spite of the short. Only the shorted winding itself will have zero volts on it. This makes shorted scan derived B+ sources incredibly easy to isolate. During this test, the 2nd anode voltage is being limited to approx 5 kv by the scanner.

If a short is present, the red "flyback" light will either lite, or flash (at various speeds), depending on which type of a short exists. If no shorts exist, the "flyback" light will be green.

Assuming that the "flyback" light is green, no **shorts** exist and, it is now time (and safe), to begin looking for **open** circuits which might be causing the set to shut down due to flyback run-a-way. It only stands to reason that if no shorted conditions exist, then one (or more) circuits will have to be open, otherwise, the TV set would be working!

(4) Now that you know that no **shorts** exists, push the "run" side of the test / run switch (the side that latches). Provided all of the other circuits in the TV set are functional, the scanner will now put a picture on the set's CRT screen that has full vertical and horiz deflection, normal audio, video and color.

Keep in mind that during this test, your scanner is:

(1) Circumventing all horiz osc/driver related shut down circuits,

(2) Limiting the set's 2nd anode voltage to approx 20-25 kv,

(3) Substituting the set's horiz osc/driver circuit and, as a result, eliminating any need that the set might have for an initial start up or B+ resupply circuit for the osc/driver.

Wait about 15 seconds for its filaments to warm up, then look at the CRT. Any circuits that are **"open"** will now produce an obvious symptom on the screen. Because the scanner has circumvented all of the set's shut down features, you can now use your old reliable "symptom to circuit analysis" technique to troubleshoot the problem, i.e., if the picture has no blue in it - - - repair the blue video or blue matrix circuit. If the picture has only partial vertical deflection - - - repair the vertical circuit, and so on. The scanner has effectively removed all of the stumbling blocks that would normally prevent you from diagnosing the problem, i.e., start up and shut down features, and allowed you to repair the TV set by using conventional techniques.

When you're using a scanner, all start up, shut down, dead set problems are easy to solve. You don't need anyone to tell you just how difficult these problems can be for those who don't have a scanner!!

Our Super Tech HV circuit scanner normally sells for only \$495.00. Beginning July 4, 1985 thru August 31, they are on sale for only \$395.00.

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CIRCLE 274 ON FREE INFORMATION CARD

cated on the side of the scanner and the other located beneath it, are used to rotate the scanner. The steppers allow for almost complete rotation in the vertical and horizontal planes. About the only area that can not be "viewed" is straight down.

The *Scorpion* "scans" by sampling light levels in the vicinity of the robot. That is done by a small photo sensor mounted at the end of the scanner facing the parabolic mirror. The *Scorpion* control system contains an A/D conversion circuit that interfaces with the 6502 and allows your programs to make decisions based on light conditions the *Scorpion* encounters.

In addition there are two pinpoint light sources that Rhino calls "eyes;" they may be turned on and off under operator control, and may be used to add "personality" to the *Scorpion*. There is also a beeper that may be used to the same effect,

The *Scorpion* command system

The *Scorpion's* 8K ROM operating system includes 30 commands for controlling the robot. Each command begins with a slash (/), and many commands are followed by one or more values that the user must supply. For example, the instruction */7M + ## − ##* means "START BOTH MOTORS." The pound signs represent the speed at which each motor is to turn. Plus (+) and minus (−) signs are used to refer to the forward and reverse directions, respectively.

You can command the *Scorpion* to move forward, backward, and through all turns at various speeds. Note that there are no commands that move the robot a specific distance; the commands available turn the motors on and leave them on until you explicity turn them off.

By varying the speed of each motor it is possible to turn the *Scorpion* in very small increments. You can also turn it, as we discussed in last month's column, by running one motor in one direction and the other motor in the opposite direction.

Other commands control the operation of the scanner. When doing a scan, the *Scorpion's* 6502 actually stores the light-level data in on-board RAM. That data can be transmitted back to the host system where it can be processed and used for obstacle avoidance, object recognition, etc.

A tracker assembly on the bottom of the *Scorpion* may be used for automatic guide-way experimentation. The tracker is composed of two photo-detectors, each with its own light source, mounted about an inch apart. The guide-way could be a strip of black tape (or reflective tape.)

System expansion

You might want to add commands to *Scorpion's* repertoire, or expand its hardware capabilities. To help you do either, Rhino has provided a 130-page manual that contains assembly instructions and some very interesting reference information. Included in the rear of the manual is a well-commented source listing of the entire operating system. The listing contains numerous hints for adding your own code and modifying the built-in commands.

Mechanically, everything is put together with screws—there are no welded pieces. So that makes it simple to change motors or other components. The enclosure comes with holes pre-drilled along the sides. The spacing of those holes conforms to the *"Erector Set"* standard, so you can easily add to the robot's structure. Just be careful not to put too much weight on the unit, or the wheels might slip.

The *Scorpion* has been out on the market for over a year. However, the price has recently been halved. At press time it's about $350 for the complete kit.

There is a user's group (Scorpion Users' Group, MJR Digital, P.O. Box 630, Townsend, MA 01469) that distributes a quarterly publication with programming notes, new operating systems, hardware-expansion ideas, and products for sale. It's been my experience that once a users' group starts up, there seems to be enough momentum generated to keep things going for several years, even if the manufacturer folds. The *Scorpion* can provide an excellent tool with which to start learning about robotics. I recommend it. **R-E**

SATELLITE TV

continued from page 32

na-mounted amplifier/converter, may be retrofitted with a 12-GHz LNB, and that will allow the customer to select either 4-GHz service or 12-GHz service. So far so good.

It is the dish that presents a special challenge. The home-TVRO industry has adopted "mesh" dishes for 4 GHz because the open-wire mesh design works well, ships easily, and is cost-effective. Unfortunately, mesh dishes are designed to work well at 4 GHz, and work very poorly—if at all—at 12 GHz. Tests conducted on popular, high-grade mesh dishes at 12 GHz indicate that they have efficiencies of 20% to 25% at 12 GHz. That is a far cry from the 55% to 65% efficiencies obtainable at 4 GHz. But efficiency, or bulk gain, is not the real problem; dish stability is.

A large mesh dish, perhaps 10 to 12 feet in size, may develop enough gain, even at 20% efficiency, to make a 12-GHz system perform acceptably. But the dish-mount and tracking system using a motor-drive and a polar-mount satellite-belt tracker technique is a big problem.

Recent tests have revealed that the amount of "slop" or "wobbling" one finds acceptable in a tracking system at 4 GHz is totally unacceptable at 12 GHz. Why? Because the dish has much narrower beamwidth at 12 GHz than at 4 GHz. Tolerances increase by a factor of 3 in the change-over from 4 GHz to 12 GHz. So, where 0.5-inch dish play (about the maximum acceptable at 4 GHz) may be easily obtainable, 0.5/3 = 0.167-inch play will be difficult, if not impossible, to obtain with equipment currently on the market.

Those are solvable problems, but they are not solved yet. When the solution is found, all systems now in place will have to be appropriately retrofitted if they are to receive Ku-band signals. In the meantime, the 4-GHz scrambling snafu keeps getting more and more complicated, and that is driving system planners to serious consideration of 12-GHz. **R-E**

DRAWING BOARD

ROBERT GROSSBLATT

Control signals of the Z80 microprocessor

I SAID IT LAST MONTH, BUT I'LL SAY IT again. Before beginning our journey into microprocessor land, you must have a road map. The only way you're going to get anything out of our discussion is to have a good Z80 databook in front of you. If you don't have a databook, you can use the diagrams from last month's column.

The registers

The registers are the easiest part of the IC to understand. After all, they're nothing more than simple memory, similar to the RAM (*R*andom *A*ccess *M*emory) we spent so much time talking about a few months ago. What's unique about the registers is that they are located inside the Z80 itself. There are basically two kinds of registers: those that can only be accessed by the Z80, and those that are accessible to us.

The Z80, like any other microprocessor, spends its time following the instructions we give it. It uses certain registers to keep track of what it's doing, where it's going, and to store interim data. The other registers—the ones accessible to us—are pretty much the same as other memory you might interface to the microprocessor. The main difference is that they're part of the IC itself, and that provides two advantages over to external memory. First, the Z80 can get to the registers quicker than to external memory, and second, it leaves the external data bus free for use by other devices while the Z80 is busy internally.

The Z80

Figure 1 shows a pinout of the Z80. I've grouped the pins by function in order to show relationships between various groups of signals. The data and address buses are shown along the left side of the diagram, and the control signals along the right side.

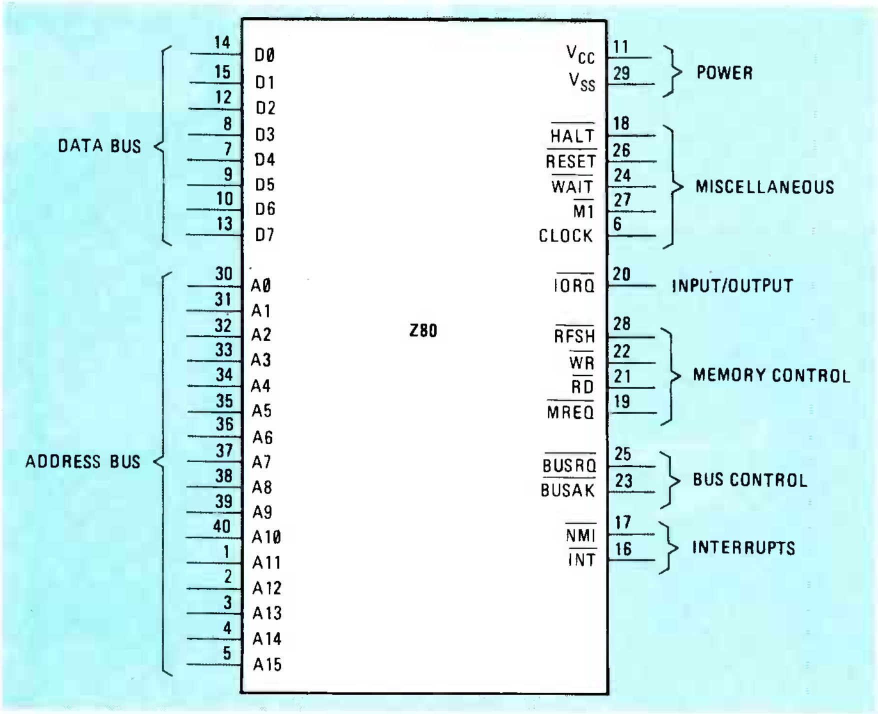

FIG. 1

The width of the address bus (i.e., the number of address lines) limits the number of external memory locations the Z80 can reference without resorting to special tricks. Since there is a total of 16 lines, the IC can directly access 2^{16}, or 65,536 locations.

The operation of the address and data bus controllers, and the ALU, are all affected by the state of pins 16 to 28. So let's take a look at them now.

Bus control signals

Typically, a microprocessor-based system will have several different devices interfaced to its address and data buses at any one time. But since only one device at a time can have control of those buses, the microprocessor needs to be informed when another device wants control. That task is taken care of by the BUSRQ (*BUS ReQ*est) input. A device that needs control of the bus sends a low to that pin. When that signal is received by the Z80, two things happen in sequence. First, both buses are tri-stated (placed at a high impedance) so that other devices can access them. Second, the Z80 lets all the interfaced devices know

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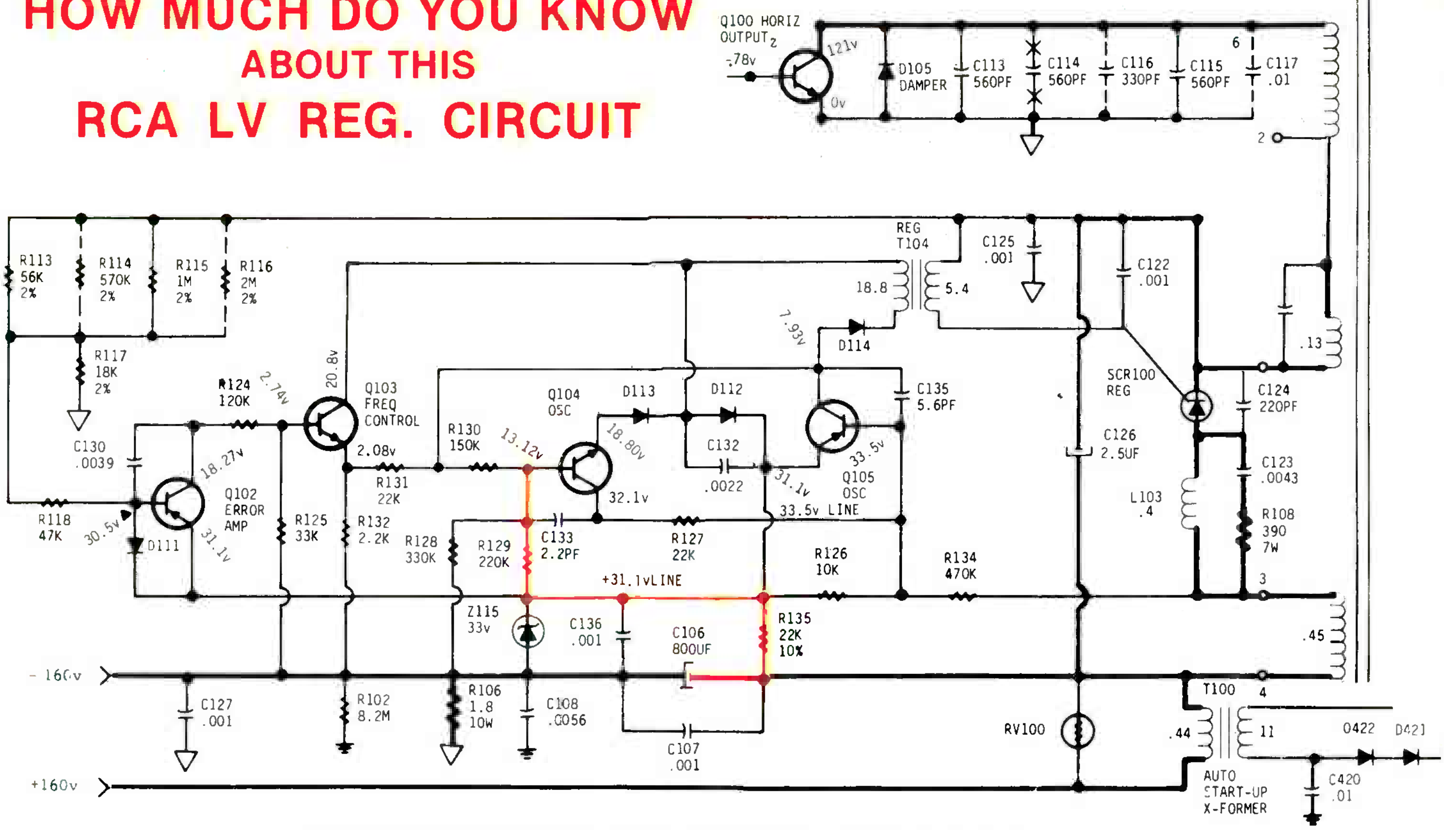

Typical of RCA CTC 85 thru 108 LV Regulator Circuits

Schematic by Diehl Engineering

How many of these questions can you answer ?

(1) Every circuit has a beginning and an ending. Where does this circuit begin ?
(2) Specifically, what is the purpose of this circuit ?
(3) What turns it on ? What turns it off, or does it ever really turn off ?
(4) Does this circuit have a shut down feature ? If so, which components are involved ?
(5) What would happen if Q103 were to become shorted E to C ?
(6) What purpose does Z115 serve ?
(7) What would happen if D114 became shorted ?
(8) What purpose does C126 serve ? What will happen if C126 becomes open ?
(9) Is the winding between terminals 3 and 4 of the flyback a primary or a secondary winding ?
(10) What purpose does C117 serve ? Exactly what does it do, and exactly how does it do it ?
(11) Exactly what do resistors R113, 114, 115, 116, and 117 do ? What happens if they change value ?
(12) What occurs that causes this circuit to produce an initial start up pulse ?
(13) Why does this entire circuit become shorted and begin to destroy horiz output transistors if the regulator SCR becomes shorted ?
(14) There is exactly one safe and practical method of circumventing this LV regulator circuit for test purposes. This technique does not involve a variac. Instead, you must disconnect one wire then connect a jumper wire from terminal #4 directly to .... Which wire do you disconnect and where do you connect the other end of your jumper wire ?
(15) If SCR100 is shorted, this circuit will still "eat" horiz output transistors even if you are using a variac. Why ?
(16) Why does this circuit use a floating ground ?

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that the buses are available by placing a low on the $\overline{\text{BUSAK}}$ (*BUS* Ac*K*nowledge) output. The buses stay tristated as long as there is a low on the $\overline{\text{BUSRQ}}$ input.

Memory-control signals

The most complex signals on the Z80 are those controlling external memory. Whenever the Z80 wants to access that memory, it puts a low on pin 19, the $\overline{\text{MREQ}}$ (*M*emory *REQ*uest) line. That signal tells the rest of the circuit to release the data and address buses because the CPU wants to do something with external memory. Whether it's a read or a write depends on the signals found on pins 21 and 22, the $\overline{\text{RD}}$ (*R*ea*D*) and $\overline{\text{WR}}$ (*WR*ite) signals.

When the Z80 wants to read the contents of a particular memory location, it puts lows on the $\overline{\text{MREQ}}$ and $\overline{\text{RD}}$ lines. That informs the rest of the circuit that the CPU is going to do a read. Likewise, it should come as no great surprise to learn that when the Z80 wants to do a write, it put lows on the $\overline{\text{MREQ}}$ and $\overline{\text{WR}}$ lines. Of course, the Z80 reads and writes data only after giving the address bus time to stabilize.

$\overline{\text{MREQ}}$ is similar to signals we've generated in circuits that we've designed in previous columns. In both the keyboard encoder and the memory-demonstrator we generated signals that were used to enable various circuit elements at different times. Well, $\overline{\text{MREQ}}$ is just such a signal. When you dissect Z80 circuits, you'll always find that the $\overline{\text{MREQ}}$ line is tied, either directly or through some other circuitry, to the enable lines of external memory. Once the memory is enabled, the $\overline{\text{RD}}$ or $\overline{\text{WR}}$ lines is used to prepare memory for a read or write.

The last line associated with memory is the $\overline{\text{RFSH}}$ (*R*e*F*re*SH*) line at pin 28. When we were discussing dynamic RAM a few months ago, I told you that even though refresh can be a pain in the neck, there are LSI IC's that ease a great deal of that pain. Well, the Z80 also has built-in circuitry that makes the job easier.

In order to refresh most dynamic RAM, you can periodically read the contents of each cell out and write it back in. However, there's a simpler way; as you'll remember from previous discussions, reading any one memory cell causes all cells in that entire row to be refreshed. Also, a row can be refreshed by simply addressing one of the cells in the row. So the refresh hassle would be simpler if we had a circuit that would increment an address counter. We would use that counter to address successive rows in the memory array automatically. And that's exactly what the Z80's *R* register does for us.

In order to understand how it works, let's digress for a moment and talk about how the Z80 processes the instructions you give it in a program. The first thing the Z80 does as it prepares for each new instruction is to fetch that instruction from memory. After the instruction has been fetched, the CPU spends some time decoding the instruction, and the outcome of that determines what the CPU will do next. So immediately after every instruction-fetch, the Z80 is busy internally and has no need for the address and data buses.

Once the instruction fetch is complete, the Z80 does four things in sequence. First it increments the *R* register, and then it places the contents of that register on the lower seven bits of the address bus. Next, it brings the $\overline{\text{MREQ}}$ and $\overline{\text{RFSH}}$ lines low. At that point the contents of the *R* register have stabilized, and may be used by external circuitry. Then it's up to that circuitry to use those signals to refresh dynamic RAM.

Other control signals

Of the control signals left, the only one that really interests us at the moment is $\overline{\text{RESET}}$. Undoubtedly you've seen that kind of signal before. With the Z80, bringing that pin low causes all bus and control lines to go into a high-impedance state; further, the program counter and *R* register are set to zero, and, in general, the CPU is brought to a very-well-defined state so that the software will be able to build on that.

Fortunately the Z80 is more difficult to write about than it is to use. Next month we'll find out how to talk to the Z80, and actually build a bare bones system—expandable, of course. **R-E**

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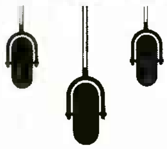

When stereo movies are made, three microphones are used instead of the normal two. The sound from the rear microphone is encoded and split onto the left and right front channels. There it stays completely unheard and unnoticed, unless it is decoded.

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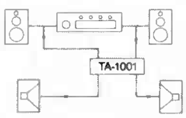

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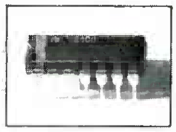

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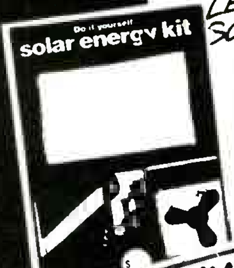

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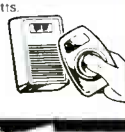

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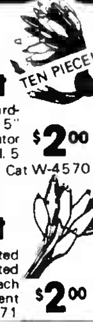

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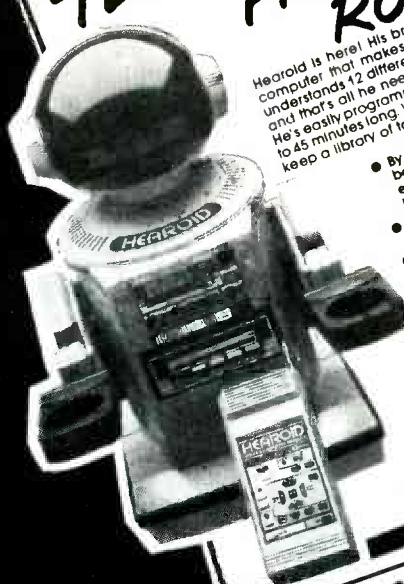

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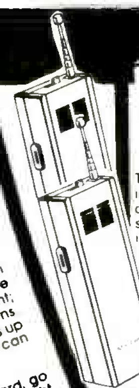

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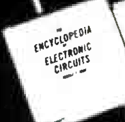

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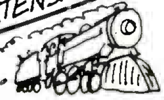

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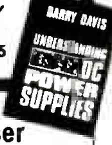

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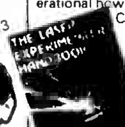

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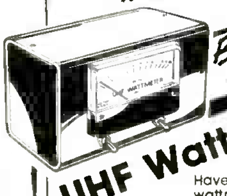

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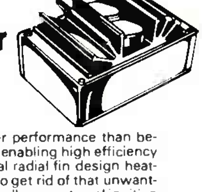

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DESIGNER'S NOTEBOOK

ROBERT GROSSBLATT
CIRCUITS EDITOR

And the winner is...

BACK IN AUGUST OF 1984, I CHALLENGED you to come up with an unusual one-gate circuit. At the time, I promised that the person who sent in the best one would be rewarded with a one-year subscription to **Radio-Electronics.** Well, response at first was quite disappointing, but after a gentle reminder a few months later, some really good circuits began to come in. And now its time to announce the winner.

Stan Barzee of Terreton, Idaho sent me the siren circuit shown in Fig. 1. It uses only a few components, and it is easy to build. In addition, the siren's sound can be customized by varying the values of several of the components.

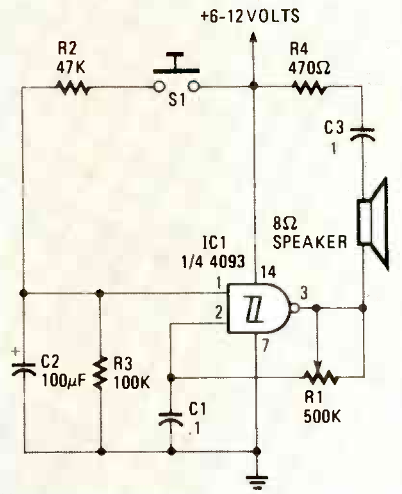

FIG. 1

How it works

When switch S1 is depressed, C2 begins charging through R2, and the gate starts oscillating. As charge builds up on C2, the frequency of the oscillator begins to increase, and does so until the capacitor is fully charged. When S1 is released, C2 begins to discharge through R3, and the frequency of the oscillator begins to decrease. If the input to the gate at pin 1 were simply shorted to +5 volts, the circuit would oscillate freely with no up-and-down effects.

Probably the most interesting thing about the siren is that Stan is able to drive an eight-ohm speaker directly from a CMOS gate. That's something we're usually told not to do. It's the Schmitt trigger that gives us the added drive capability, and the hysteresis inherent in Schmitt-trigger gates is necessary for the circuit to oscillate.

Here's how to vary the siren's sound. Increasing the value of R2 will lengthen the rise time, and increasing the value of R3 will lengthen the decay time. Keep the value of R3 at least twice that of R2 or the circuit may not oscillate at all. You can change the rise and fall times together by changing the value of C2. Increasing it will lengthen both times and decreasing it will shorten both.

As the value of C2 increases, it takes longer and longer for enough charge to build up to get the circuit oscillating. With very large values of C2, that time could stretch out to ten or fifteen seconds, which may or may not be a drawback, depending on your application.

Stan mentions that you can use a crystal microphone or earpiece in place of the speaker, R4 and C3. However, the best thing is to build the circuit as it's shown here first. Once you've got it working, you can start experimenting with different components for the effects you want.

Thanks again Stan; you've won a one-year subscription to **Radio-Electronics**. I'll keep the contest going and occasionally publish some of the better circuits. Of course, every winner will get a free subscription and a chance to see his name in print. So once again I'm asking all of you out there to look through your design notebooks and send in any clever little one-gate circuits.

The rules are simple. You may use as many diodes, transistors, and passive components as you want, but the heart of the circuit has to be one simple gate. I've told everyone around here that you people are the smartest readers of this magazine—so let's see what you come up with. Don't let me down! **R-E**

"It's not so bad, but I could get the same effect with a synthesizer."

COMMUNICATIONS CORNER

HERB FRIEDMAN,
COMMUNICATIONS EDITOR

Infrared communications

ASK ANY TEN PEOPLE TO DEFINE "COMmunications" and you'll probably get 11 correct answers. Communications is simply the way we convey information. (And everyone has his own specific needs when it comes to information.)

Many can remember when communications meant things like radio, telephone, teletype, telegraph, etc.

Somewhere along the way, the term communications came to mean almost anything. For example, no longer do we teach grade schoolers to read and write; instead, we teach them to communicate. And later, it's off to college where they study communications: how to produce TV and radio shows, and films, write scripts, edit films, and most important, criticize the work of others who show even less promise.

I still believe communications has to have some element of magic, and that it must do its thing in real time. Of course, the computer has added some truly magical quality to real-time communications, but every once in a while we find that the latest breakthrough in the state-of-the-art is nothing more than an old idea resurrected from obscurity.

Back in the golden age of electronics projects, I, as did many others, experimented with infrared devices. We made *invisible light* beams and detectors, which sounded a bell or alarm if someone interrupted the beam. We even built projects that enabled us to talk on a beam of light. Later, we used LED's and solid-state infrared detectors to once again talk via light beam (for a distance of about two feet).

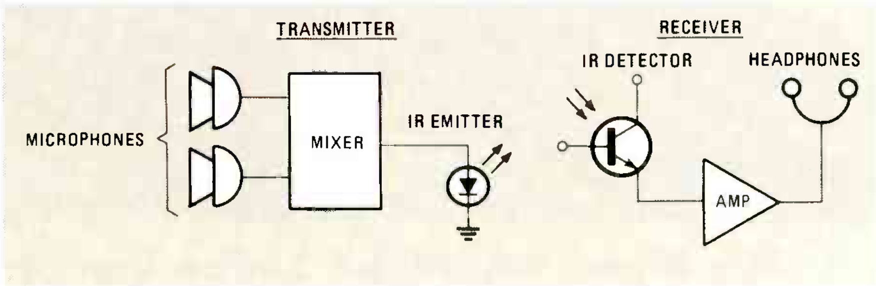

FIG. 1

Two feet became five feet, then ten feet, and finally someone designed a gadget for connection to a TV or Hi-Fi that sent an invisible beam of sound across the room to headphones that had infrared detectors in each earpiece. The gadget worked, but was not cost-effective.

However, as is common to our world, technology eventually reduces the price of just about everything. While the Hi-Fi sound transmitted to a headphone by light beam wasn't a commercial success, the same idea is now being resurrected to provide personal amplification in many theaters—a way for the actors to communicate directly with individuals in the audience. The old *talk-on-a-light-beam* construction project is now being used to bring real-time entertainment to the hard of hearing.

How it works

Figure 1 shows a block diagram of the talk-on-a-light-beam system. There's nothing spectacular about the design. Other than solid-state circuits, which make the combined receiver and headphone unusually light, it's the same old light beam project that we used to build for the science fair.

What's different about the system is that it's almost interference free. It's even possible to place your fingers in front of the detector and, if there is the slightest space between your fingers, the system still works. Because several transmitters are used to send the signal, the light beams strike the detector from every possible angle. A little energy manages to sneak past any opening, no matter how small.

Microphones spread across the stage pick up the stage sounds (signals). The signals are mixed and fed to several transmitters mounted at the front of the theater on each side of the stage. One pair is mounted low for the orchestra and the other pair is mounted high for the balcony. The transmitter is really nothing more than a box containing an infrared emitter, a power supply for the infrared emitter, and a small audio power

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amplifier that drives the infrared emitter.

Whether the person seated in front of the user is small, large, wearing a hat, or has an over-done hair style makes no difference. If the beam from one transmitter is obstructed, the beam from another is there to take its place. In testing the system, we even turned around and faced the rear of the auditorium. As you might expect, the signal eventually dropped out, but we had good reception for better than 300-degrees because the input signal originated from several well-spaced transmitters.

The receiver looks very much like the headphones you get on an airplane (with a transducer at the center from which "pipes" lead to each ear). But unlike the airplane headphones, the infrared headphones have a small receiver at the center, and the pipes terminate in real sound transducers, like those used for cassette players.

At the bottom of the receiver is a small rechargeable battery, about 1 × 0.5 × 0.25 inches, that plugs into the receiver. It really hangs below the receiver so it can be simply pulled out and plugged into any convenient outlet for recharging.

On the front of the receiver is a volume control, power switch, and an infrared detector, feeding what can easily be described as a high-fidelity amplifier and headphone. And the sound quality is as good as the best of the *Walkmen* tape players.

Infrared communications works very well over a relatively short, direct path. Because it's inherently a high-fidelity system (in the sense it can transmit a wide spectrum without special equalization), it's useful for much more than just wireless sound, as witnessed by TV remote controls.

There is no reason why the two functions (control and sound) cannot be multiplexed on the same carrier beam. Just imagine an infrared light-beam gizmo in the base of a communications microphone. The sound and control switching would go to the transceiver without intervening wires to snag around the legs: Probably the safest way to operate a mobile radio short of parking. **R-E**

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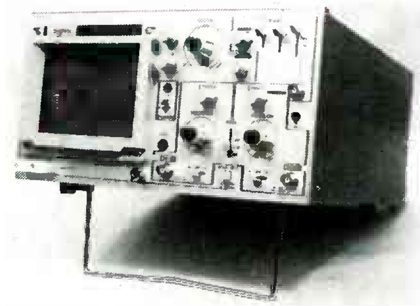

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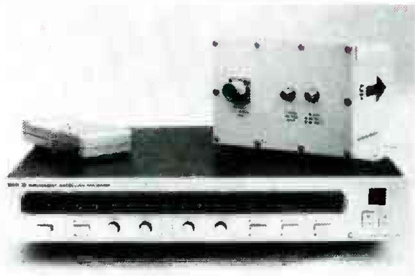

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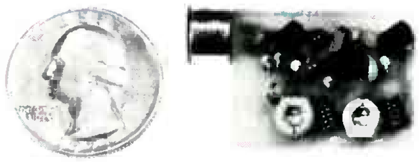

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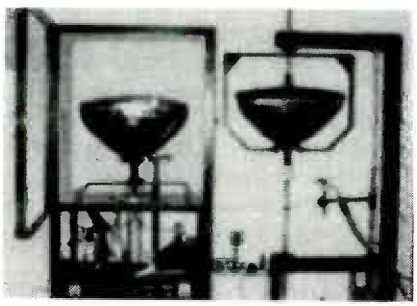

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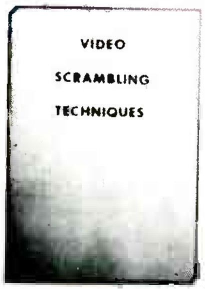

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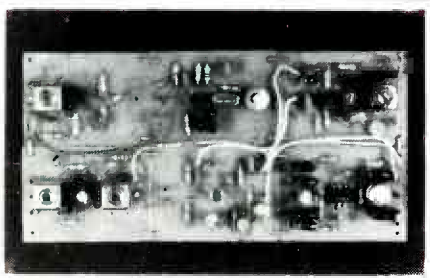

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ANTIQUE RADIOS

RICHARD D. FITCH

Common restoring problems—and solutions!

WHILE SOME ANTIQUE RADIOS SUFFER from chassis problems, cabinet problems are actually more common. So if you're going to take the antique-radio hobby seriously, and you don't want your electrical handiwork to go unnoticed, then cabinet repair *must* be in your bag of restoration tricks. If you've got your hands full just working on the chassis, cabinet work can be a good way of getting other family members involved. Just be sure to remember (and teach your family) the proper safety precautions. You already know that working on the chassis can be dangerous if you're not careful, but so can working on the cabinet. Make sure that gluing and sanding are done in a well-ventilated area, and that masks are worn.

The first set we'll look at, which we'll call the "Antique Radio of the Month" is the Kennedy *Model 20*. That radio just needed a little woodworking to make it a handsome addition to our collection. As with many antique radios, that set has a veneer finish.

While a high-quality radio that has had very good care might sneak by with just a good polishing, that rarely happens. A large majority of antique radios have spent many years stored in unfavorable environments. So if your radio hasn't been one of the lucky ones, you'll have to learn how to replace some or all of the veneer.

Veneer basics

Veneer is available locally in many areas, or it may be purchased by mail. Regular veneers

FIG. 1

come in thicknesses between 1/40-inch and 1/12-inch, and are made from about thirty different kinds of wood. Flexible veneer is suitable for many applications, especially curved surfaces. However, it is so thin (1/64-inch) that it can't be butted up against a thicker piece without shimming or sanding.

The best way to attach veneer to flat surfaces is with hot-melt glue. Spread the glue with a glue gun, seat the veneer, and then use an old electric clothes iron to re-melt the glue. You may have difficulty using an iron on curved pieces. If you are unable to use an iron, you'll have to use wood glue or contact cement (which requires much patience and a steady hand).

The Kennedy *Model 20*

While I don't know the exact age of that classic floor radio, judging by the cabinet and chassis I'd guess that it comes from about 1928 or '29. I learned everything I know about the manufacturer from the owner's manual I got when I found the radio. (First time that ever happened!) Unfortunately, the "Colin B. Kennedy Corporation of South Bend, Indiana" is no longer in existance. The manual states that the company had seventeen years of experience building radios. That would date Kennedy's origin to the early 1900's.

The first thing I did to get that relic back into working condition was to fumigate it. Next I removed the damaged veneer. I tried to get it off in one piece, but as you can see in Fig. 1, I wasn't very successful. After all the veneer was removed, there was a gummy residue left on the cabinet. To ensure that the hot-melt glue would adhere, the residue had to be scraped and sanded off.

Because the veneer stock wasn't wide enough, two smaller pieces had to be butted together. The hard part about butting veneer is getting the edges to meet evenly. However, if you overlap the edges slightly and cut through both pieces at once, you can be sure that both pieces will join perfectly.

An electric iron was used to re-melt the glue and press the veneer into place. It takes considerable heat to re-melt the glue through the veneer, so it's a good idea to place a thin sheet of aluminum between the iron and the veneer so that glue soaking through the veneer won't gum up the iron. In any case, clamps must be used to hold the veneer flat until it cools. Once the veneer has been glued down, you can sand and stain it.

Chassis repair

When I first powered the *Kennedy Model 20* up—after the usual safety inspection—it actually worked, but there was a loud, clashing noise. The chassis was still out of the cabinet, so I removed all the removable components and inspected them. Everything seemed OK. After reassembling the radio, the problem was gone. I wish all chassis problems were as easy to repair!

FIG. 2

Unlike the cabinet, there is little danger that the chassis will *ever* deteriorate. The Kennedy has one of the heaviest and most completely shielded chassis I've ever seen. It is built from "16-gauge, cold rolled, auto body steel," according to the owner's manual. It is plated, as are all of the shields. As you can see in Fig. 2, the bottoms of the tube sockets are also shielded. In addition, the four gangs of the tuning capacitor each have separate shielded compartments. Clearly, the heavy brass plates of that capacitor were not meant to be bent. Another plate shields the bottom of the receiver.

Technical specifications

The *Kennedy Model 20* has a tuning range of 200 to 500 meters (the AM broadcast band). The receiver uses a 7-tube circuit with 4 tuned stages to cover that range. The tuned circuit is composed of a three-stage RF amplifier and a tuned detector. In addition, there is a two-stage audio amplifier that uses two UX245 or CX345 power tubes in a push-pull arrangement. Because of that design, the reception is excellent.

The *Kennedy Model 20* even has an input for a phonograph. A little lever just above the power switch directs either the detected RF or the phonograph's output to the audio stage.

The *Arvin 444*

The *Arvin 444* shown in Fig. 3 sat in my junk pile for a long time. I couldn't see how such a small radio could have so much wrong with it. Two of the four tubes were missing, as were the knobs. The radio also had a bad filter capacitor and a torn speaker cone. With all the electronic problems, not to mention the fact that it had been brush-painted green, I decided to "file" this antique with the others that were too new, too far gone or, for some other reason, were not worth restoring.

Then one day, when browsing through an antique shop, I saw an *Arvin 444* with an ivory cabinet sitting on a velvet-covered table. It looked like the Hope diamond.

The shop-keeper came over and said, "That's a rare little radio; it's the only one still in existence!" He then offered to sell it to me for $75. I didn't take it, but you can bet that

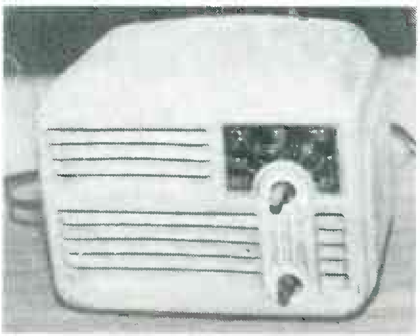

FIG. 3

when I got back home I retrieved my little *Arvin* from the junk pile. It is now restored and has a permanent place in our collection, being "one of only two in existence!" **R-E**

STATE OF SOLID STATE

Precision op-amps

ROBERT F. SCOTT

PRECISION OPERATIONAL AMPLIFIERS are the mainstay of medical and industrial instrumentation. Linear Technology Corporation recently introduced the LT1014 precision op-amp, which is the first improved replacement for such industry-standard, 14-pin quad op-amps as the LM324, LM348, OP-11 and 4156. The LT1014's 50–μV offset voltage, 0.3–μV/°C drift, 0.15–nA offset current, open-loop gain of 8 million, 117–dB common-mode rejection ratio and 120–dB power-supply rejection ratio definitely place it in the precision class.

The offset voltage of the LT1014 is so low that no offset adjustment terminals are provided on the IC. A new and improved output stage draws only 350 μA, can source or sink more than 20 mA, and still retains high voltage gain.

Another member of the family, the LT1013, is the first improved direct replacement for industry-standard, 8-pin dual packages such as the MC1458/1558, LM148 and OP-221. The LT1013's specifications are similar to, but slightly better than, the LT1014's.

Both the LT1013 and the LT1014 can be operated from a single 5-volt supply. The common-mode input range includes ground, and the output can swing to within a few millivolts of ground. Crossover distortion, a characteristic of early single-supply designs, has been eliminated. Linear Technology gives complete specifications for both single-ended 5-volt and ±15-volt operation.

Absolute maximum ratings are: supply voltage: ±22 volts, differential input voltage: ±30 volts, input voltage: equal to the positive supply voltage. Operating temperature range is −55°C to +125°C for devices with the AM and M suffixes, and 0°C to +70°C for devices with the AC, C and D suffixes.

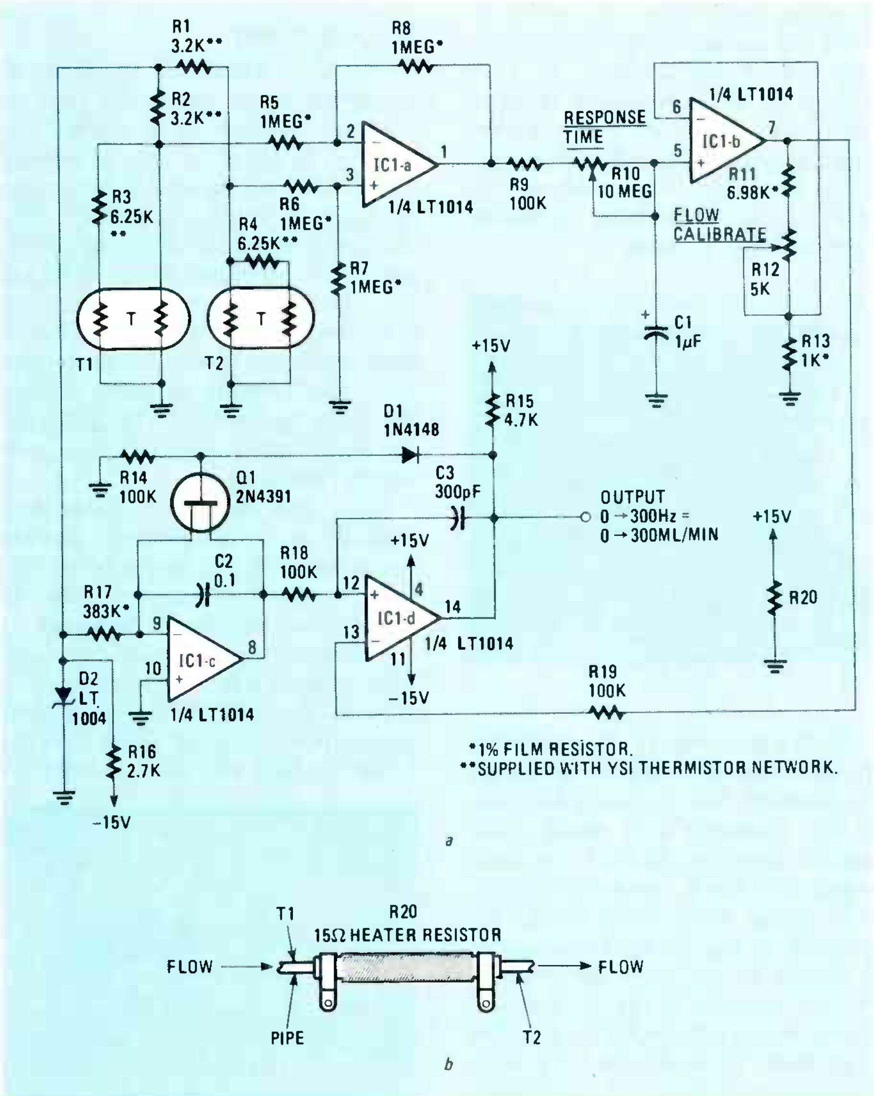

FIG. 1

Using the LT1013 and LT1014

In earlier single-supply designs using such devices as the LM124, LM158, OP-20, and OP-221, if the input goes more than a few millivolts below ground, two kinds of problems may occur, both of

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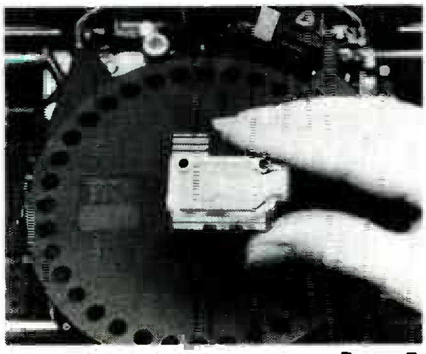

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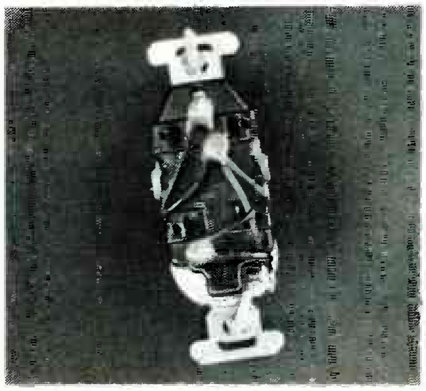

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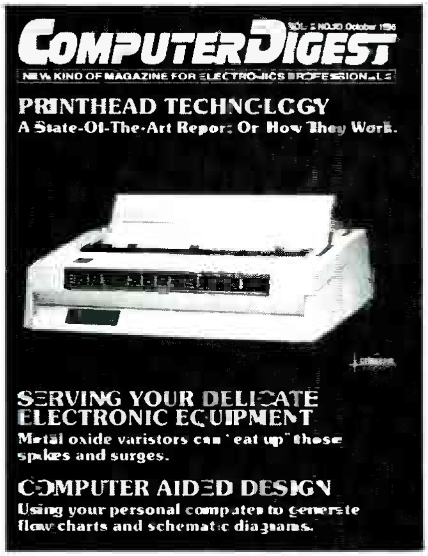
ON THE COVER

The IBM Quietwriter™ printer is typical of modern, up-to-the-minute technology. You can read all about it in the article starting on page 5.



COMING NEXT MONTH

If you've been saving to buy a modem for your Commodore 64, here's the first of a two-part article on how to build one instead.

EDITORIAL

"Hackers are morons..."

■If you want to raise a furor, use the above sentence in the computer community. I did, in my August issue editorial. The mail and telephone calls are *still* coming in. Most of the people that contacted us are involved purely in the semantics. "A hacker," said one, "is an experimenter that 'hacks away' at a computer to make it do something else."

But even this man admitted a distaste for the guy who illegally burrows into another computer system, just to show that he was able to do it! And these very people call themselves hackers!

I have no gripe with the guy who experiments with computers within the confines of his own realm. That's our *reader*! I'm down on the nut that thinks he deserves a medal for having broken into somebody else's computer system and loused things up just to show that he was able to.

And *that's* what's called a "hacker." By the general computing community, and by those morons (see? I said it again!) themselves.

The fact remains that a problem exists. A "hacker" is a thief, a criminal, who uses a computer to break into other computer systems where he has no business. This term is widely accepted throughout the computer industry.

A "computer experimenter" is *not* a hacker. Many of the innovative practices in the computer industry are the result of the work of such experimenters. And from a selfish standpoint, it is the experimenter that **ComputerDigest Magazine** is dedicated to.

Too many "computer experimenters" are fond of denegrating their work and/or hobby by calling themselves "hackers." This is a sad mistake, and I would urge that as a practice, it be halted.

So if you are a computer hacker (in our terms of reference) and that editorial ofended you, I'm certain that this one will prove equally offensive. However, I'd recommend a few courses of action to you:

Give up hacking and get into something a bit more useful—like stealing hubcaps. Do *not* send me any unsigned mail. If you don't have the guts to sign what you write and provide an address to which a reply can be sent, don't write at all.

Just to make the point clearly, for once and all, a "hacker" spends his time trying to break into computers... Government computers, hospital computers, school computers, my computers, etc. and louse up the records. He doesn't do this by any clever, intelligent means, but rather by simple, dogged, repetitive (and very boring) trial and error.

A computer experimenter on the other hand, is an intelligent, thinking individual who tries to improve his own computer or the state of the art technology in general. Whether he succeeds or fails is not important. The fact that he tries puts him in the same category as the great inventors of all time and we all owe him a debt of gratitude. The articles that you see in this magazine were written by computer experimenters.

The hackers contribute nothing to the computer community or the community in general. They give us all a bad name. If they continue to flourish, you're going to see tighter controls on all of us. And Americans, being a freedom-loving people, don't want things like that to happen.

There's a vast difference between the legitimate experimenter and the *illegitimate* hacker!

Or maybe it's just a half-vast difference.

Byron G. Wels

Byron G. Wels
Editor

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LETTERS

Complaint!

I enjoyed your Editorial in the March Issue of **ComputerDigest** but if you think Instruction Manuals are bad, you ought to see some of the Service Manuals. It's really sad. It's no wonder people need so much help in getting things to work right. It's not restricted to computers, either. Our shop gets problems on car stereos and answering machines that could be straightened out with some simplified instructions.—P. B. Mann, Atlanta, GA.

Thanks for the comments, P. B. Maybe by calling attention to this much-neglected area of technology, we'll start getting better instruction books from the manufacturers!

New idea.

Liked your Editorial on Computers and the CB Syndrome. But what about including the rising interest in amateur radio and the subsequent decline? I was impressed how amateurs did such a great job of research and development at a low cost.

Also, I've developed a device that will greatly simplify learning electronics, and need professional marketing assistance. How can I get this?—Don L. Harbertson, Morgan, UT.

Don, our prime interest, of course, is computers. We'll leave the amateur radio to those magazines that cater to that field. Of course, I agree wholeheartedly!

Harder and harder

Kids today have it rough. There is so much *more* to learn, yet the time to learn (and teach) has not been extended. Invention is also a closed field, for it takes megabucks to do research which shuts out the individual. It's now a team effort at the Corporate level. What can you recommend for a youngster looking at his future?—Bob J. Seligman, Kent, NH.

Imagination, Bob. There are no dead-end jobs, only dead-end people. You're right about there being more to learn, but education has now become vertically-specialized to compensate for this. And all inventions don't have to be Earth-shattering in scope! There's still room for the individual—Find a new type of cap for a toothpaste tube, or a new kind of paper clip.

Communications trap

Being in the publishing business, of course you're sensitive to communications. I've picked up on your interest in this area in your Editorials, too. But did anything in particular get you hyped on this subject?—Fred Mason, Hackensack, NJ.

Fred, I was once asked to write a book on "Rock" by a major publisher, and spent the next six months immersing myself in an in-depth study of geology by way of preparation. When I finally delivered the manuscript, I found out that he meant Music!

COMPUTER PRODUCTS

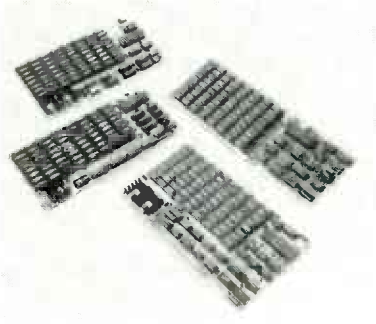
For more details use the free information card inside the back cover

ANALYZER PROGRAM, *The Landlord Investment Analyzer* is designed for real estate investors, who can produce a thorough cost/benefit analysis of properties by using it. It calculates data that is entered for a specific property, including pricing, financing alternatives, expected return, and buyer tax considerations. By objectively comparing investment options, properties that will yield the highest profits are easily identified.

The Landlord Investment Analyzer is completely menu driven, and online instructions provide immediate help. The package is available in PC-DOS, requires 256K memory and one disk drive. It is priced at $350.00.—*Systems Plus, Inc.*, 1120 San Antonio Road, Palo Alto, CA 94303.

CIRCLE 11 ON FREE INFORMATION CARD

EMULATOR, the *SemiDisk,* is a computer peripheral hardware/software disk emulator package that speeds up the operation of computer systems.



CIRCLE 12 ON FREE INFORMATION CARD

SemiDisk is compatible with IBM *PC, XT, AT,* and most IBM PC systems, and the S-100 bus, Epson QX-*10,* and TRS

continued on page 14

PRINTHEAD TECHNOLOGY

Everything you ever wanted to know about printheads.

Marc Stern

■Do you remember the days when the only "serious" computer printers were fully formed character or dot-matrix machines, while thermal printers were given short shrift as "amateur" devices?

Thermal printers are now "serious" machines, whose capabilities rival those of their fully-formed or dot-matrix brethren. In fact, the entire realm of non-impact printers, to which thermal devices belong, has undergone a revolution during the last 18 months. At the start of 1984, laser printers were available at costs exceeding $50,000 and ink-jet printing was confined to commercial ventures. Now, laser imaging printers are available for less than $3,500 and ink-jet printers in the $300 to $1,200 range abound.

Thermal printers

As recently as 1982, thermal printers were looked on as toys. They were among the first personal computer printers, but they had drawbacks. They needed special paper to operate, which tended to discolor rapidly; their resolution was too low for other than rough use, and their print quality wasn't high.

Their technology was a combination of dot-matrix printing and thermal technology.

In use, these printers—most were serial—took the output from a microcomputer and internal microprocessor-based circuitry transformed the output into text. The ASCII codes generated by the microcomputer were compared against character sets stored in Read-Only Memory (ROM) and the appropriate signals were generated for the printhead controller circuitry and printhead, which contained a number of wires. Those wires were fired by tiny solenoids into the special thermal printer paper which was "exposed" by a heater bar over which the paper traveled.

The result was a low-resolution printout of block characters, which was unsuited for any use, other than rough output. The reason for this was the nature of the printhead. It generally contained a matrix of five wires across by seven wires down, which was too coarse for quality text output. Further, the ROM-based character set usually contained only capital letters.

Crucial developments

The change occurred when thermal printing became thermal transfer printing. Instead of relying solely on the heat-sensitive paper to produce printed output, special ribbons were added. The plastic ribbons were struck by the printhead wires as the paper moved over the heater bar and the dot-matrix letters were melted onto the paper. In some cases, not only did the heater bar do the melting, but the printhead wires were also heated to help in the process. In this type of printer, the printhead serves two roles, printhead and heating element.

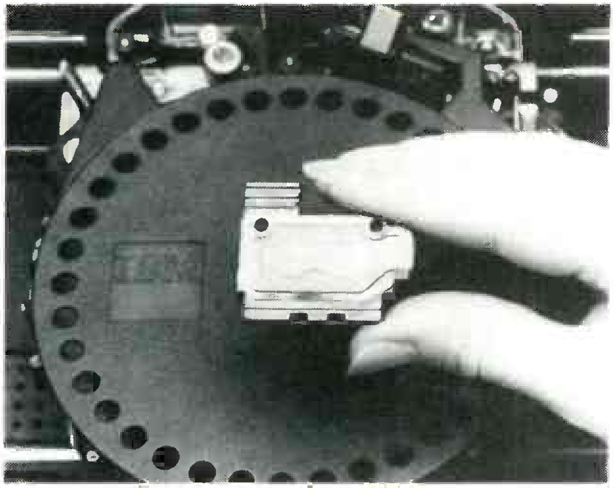


FIG. 1—FORTY TINY ELECTRODES meet at the edge of IBM's electronic printhead. In the background, is the round cassette that holds the IBM "Quiet" (TM) correcting ribbon.

A second important development came from impact, dot-matrix printer technology.

By using finer printhead wires, more sophisticated internal programming and circuitry, dot-matrix printer manufacturers were able to increase the density of their printheads. The first jump went from 5 by 7 to 7 by 9 or 9 by 9 wires. The increasing number of printhead wires meant letters could now look more normal.

The increase in density continued to the point where denser printheads became common. Densities of 18 to 24 wires or more were usual.

This type of printhead required technological sophistication because each print wire had to be fired at the correct moment and in the correct sequence. Dot-matrix printers had come of age. They were now capable of the precise control needed to generate true descenders and near-letter quality printing.

This technology was transferred to thermal printers, which are non-impact, as opposed to the impact dot-matrix printer (the dot-matrix printer's pins push through a ribbon and then strike the paper) and the result has been a new generation of thermal transfer printers whose output is indistinguishable from a fully formed character machine.

There are two types of thermal transfer technology currently on the market, the older style heater bar or heater head printer and the newer IBM-manufactured thermal transfer printer.

IBM's development is actually a breakthrough in thermal transfer technology. Although many thermal transfer printers can make use of low quality paper and can produce acceptable results, high quality printing still requires special, glossy-style printer paper. With IBM's system, you can use any type of paper.

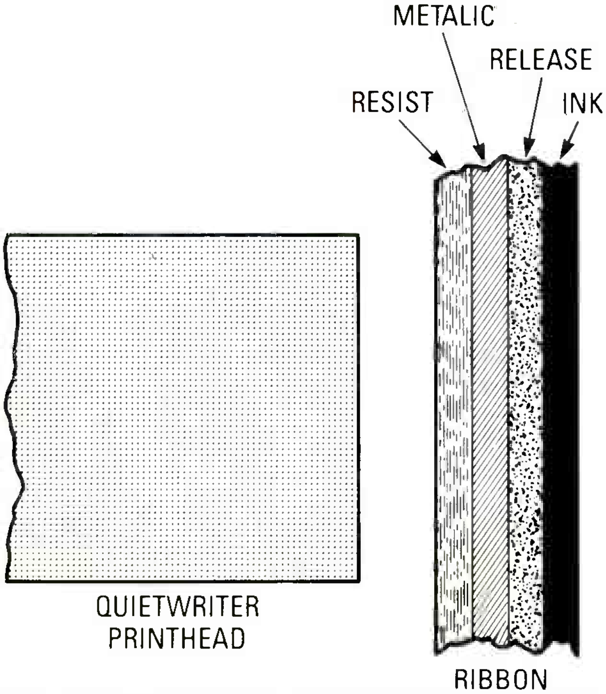


FIG. 2—THE IBM RIBBON uses a four-layer system that works with the printhead to release ink to the paper. The result is an almost-perfectly formed character that is hard to tell from what used to be called "Letter Quality."

Using a 40-wire printhead—See Fig. 1—IBM uses a variation on thermal transfer printing to achieve letter-quality printing from the dot-matrix head.

As in conventional thermal transfer printers, the text is "exposed" by heat, but, with a difference. Where the normal thermal transfer printer passes the paper over a heater bar as the ribbon is being struck by the dot-matrix pins, the IBM system uses a special ribbon that releases ink in response to pinpoints of heat generated by current in the printhead.

IBM's thermal printer uses a four-layer ribbon which consists of a polymer resist material that heats up in pinpointed areas; a metallic conducting layer; an easily meltable layer that permits the release of ink, and a film of ink.

When it is printing a character, the printhead presses the ribbon against the paper and the electrodes contact the resist layer. These electrodes apply small electrical currents that travel through to the metallic layer, with the result that up to 40 pinpoints of heat can be generated. This, in turn, melts tiny areas in the release layer and paints the ink on the paper. (See Fig. 2.)

(IBM also uses this technology on its *Quietwriter* series of electronic typewriters and correcting mistakes by reversing the process to lift letters which have been painted on the paper.)

New typestyles

Like standard dot-matrix printers, the thermal transfer printer is programmable. This programmability, among other things, means it is very easy to change typefaces. By simply inserting a new character-recognition ROM on some of these printers, you can have multiple typefaces. (See Figure 3.) The microprocessor's text-creating algorithm reads the new ROM character set if it sees that the interrupt for the ROM cartridge has been issued. This ROM replaces the printer's standard character set and the new codes are based on it.

Thermal printing has now come of age. Forty-wire printheads and printheads with 36 by 24 resolution are common and, thanks to the special plastic ribbons used, the output looks as if it comes from a fully formed character machine.

Laser imaging

Just a few years ago, laser printers cost the better part of $50,000 and were suitable only for high production atmospheres such as publishing houses or facilities where a great deal of text output was generated. However, the introduction of the Canon laser engine last year changed all that. It has brought laser imaging to market for $3,500 or less.

Capable of running at speeds approaching 8 pages or more a minute, the laser printer makes high speed, high resolution printing and graphics available at an affordable price.

Actually based on office copying technology, the laser printer replaces the document tray and copier cover with a computer interface.

(In today's copier, a bright light illuminates a printed page and a lens captures the image. The image is then digitized and deposited on a drum to which toner is applied. A piece of copier paper is then placed against the drum and an image is made.)

This is very similar to the way in which a laser printer

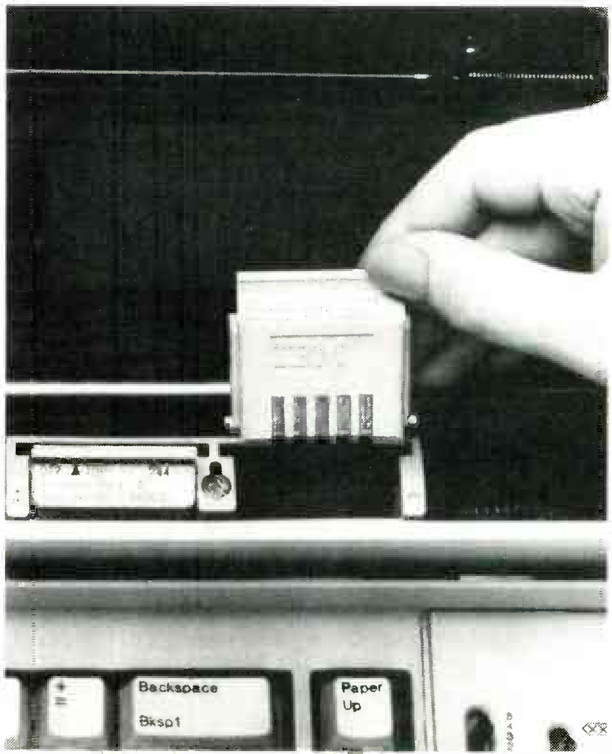


FIG. 3—CHANGING FONTS is as easy as slipping in a cartridge. Two different fonts can be placed in the printer at the same time, and the operator can switch at will from one to the other, simply by programming.

creates its images. However, instead of using a bright light and lens, the computer acts as the front end of the system. ASCII codes generated by a word-processing or text preparation program are sent directly to the laser printer's microprocessor and are stored there until a full page of text is generated.

Each letter passes not only into the printer's storage register, but, as it does, the microprocessor within the unit compares it against whatever special ROM-based character set that may be in use within the printer—italic, gothic, bold, or whatever—as it passes to storage and the text is then stored ready for release to be printed. (Actually, the point where a letter code is compared against ROM depends on where the designer of the algorithm decides to place it. It may be as it passes through the micro or it may wait until the page of text is generated and the whole page is then compared against the character set.)

When the page is released for printing, the micro then directs it to a tiny laser which recreates the text as a series of pinhole bursts of light. Each burst of laser light represents a digital piece of information which goes toward making up the letter.

The laser bursts are, in turn, directed toward a mirror-like drum coated with selenium and the letters are electrostatically etched on the drum. In turn, sooty black toner adheres to areas on the drum that have been charged by the laser and the paper which passes over the drum picks up the toner images.

One of the things you will notice about laser printing, if you look closely at it, is that it looks like a very dense dot-matrix printing. This is because of the bursts of light employed as the laser etches the text. Because of the density of the bursts, the letters look fully formed and are much darker than those produced by a dot-matrix printer.

In general, laser printers not only are microprocessor-driven, but also contain quite a bit of Random-Access Memory (RAM) and ROM. Typeface or graphics information is stored in ROM.

It isn't uncommon to find a laser printer with 64K of RAM and equally as much ROM because of the sophistication of the typefaces available and because of the sophistication of the algorithms.

A graphics-oriented laser printer, on the other hand, can have even more RAM and ROM. As much as 500K of ROM may be used because of the on-board controllers used for graphics work. Apple's *LaserWriter*, for example, contains 500K of ROM and 1.5 megabytes of RAM, as well as an MC-68000 microprocessor. This configuration provides full page graphics.

Non-laser imaging printers

Lasers aren't the only devices used for electronic imaging. Some manufacturers are using liquid crystal lenses and light emitting diode arrays to replace the laser device. For example, Epson's GQ-3000 uses an LCD shutter to create characters and images by allowing light to pass through the display. The image is then printed on the drum. (See Fig. 4.)

An LED array is used in Kentek Information Systems' K-2 copier-printer. The LED array replaces the laser to

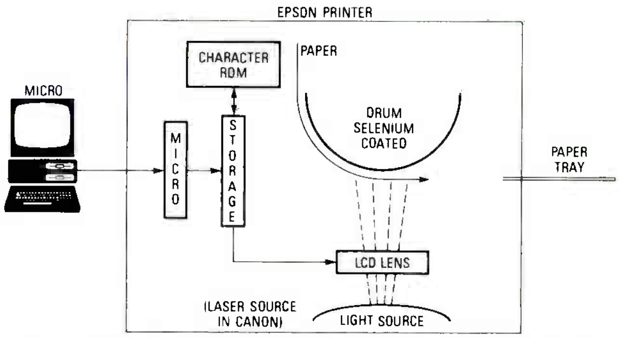


FIG. 4—HOW LASER PRINTING WORKS. Note that in the Canon system, there is no LCD. The system is fast, efficient, and exemplary. See text for fuller explanation.

create the image on the drum. Like the laser, the array creates a pulse of light for each bit of information and a fiber-optic lens focuses the pulses on the drum.

One other variation, now undergoing testing, is Phillips Peripherals' *Elpho 20*. This device uses a CRT connected to a photocopier mechanism. Using a CRT that is only one line high, a beam of blue light is emitted by the CRT and is focused on a print drum by a lens. Selenium is particularly sensitive to blue light and so it makes sense to use this. The CRT, inside the printer, takes the place of the laser, LCD or LED array.

Ink jets

Available for as little as $495, an ink-jet printer sprays droplets of ink onto a sheet of paper with sufficient force to make it adhere to that paper.

Lower-cost ink-jet printers use "drop-on-demand" technology, where the tiny droplets are ejected from the ink nozzles by a crystal which acts much as the solenoid in a dot-matrix printhead. The rapid action of the piezoelectric crystal in response to current is the factor which enables it to function as the ink pump.

Like dot-matrix printers, the printed output of an ink-jet printer is in a series of dots that resolve into letters. The ink dots correspond to the digital information passed from the printhead controller to the printhead as to the number of dots and their arrangement in making up a letter.

In some ink-jet printers a multijet printhead is used to produce color graphics. These machines have three to seven jets, each of which is connected to an ink reservoir of a different color. The order in which the program tells them to fire determines the coloring of the graphic work. The program orders a specific jet to fire at a specific time.

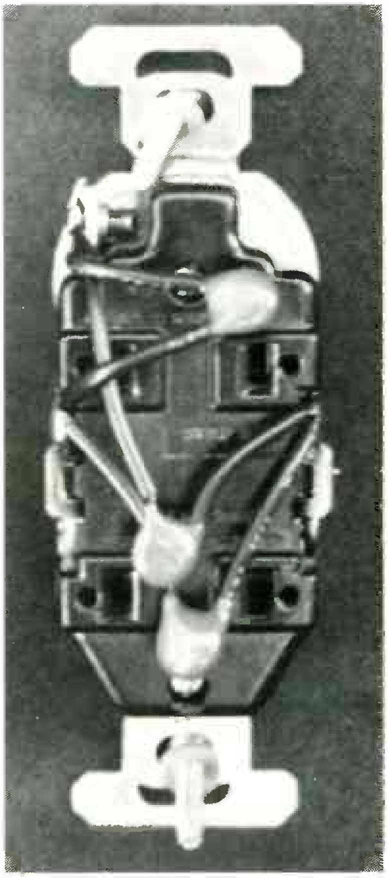
"Drop-on-demand" technology is the least expensive form of ink-jet technology. The second type used is also the most expensive, continuous stream. In this type of printer, an acoustic transducer generates sound waves which deflect droplets of ink onto the paper so they form letters. The stream of ink flows continuously and returns to its reservoir thanks to a low pressure area created in front of the printhead.

Nonimpact printer technology has taken huge strides. Printers that were once considered "toys" are now assuming a serious role. Their output is good and they offer more variety.

SAVING YOUR DELICATE ELECTRONIC EQUIPMENT

How to use MOV's (Metal Oxide Varistors) for surge protection.

ELLIOTT S. KANTER



■A lot of attention has been paid to protecting computers and other electronic equipment against power-line surges. These can be the result of either natural or man-made conditions. Examples of natural surges would be lightning hitting power lines, poles or transformers. The man-made are often the result of switching between power-line feeders or other malfunctions that originate at the source of power generation and distribution.

Regardless of the cause, the results are usually the same. Nominal line voltage (108 to 125 volts) undergoes an abrupt upward swing. Values can reach two or three times normal line voltage. Increased demands of air conditioning, power tools or heating systems cycling on the line can also produce "glitches" with similar results. The incoming line voltage rises and as a result, voltage-sensitive components inside a piece of electronic equipment are subjected to high-voltage spikes.

Let's protect everything

We don't hesitate to protect our computers and related equipment against these surges, but what about television receivers, videocassette players, stereo equipment and other electronic equipment whose value may equal the cost of our computers? We tend to regard these more as fixtures than as voltage-sensitive devices.

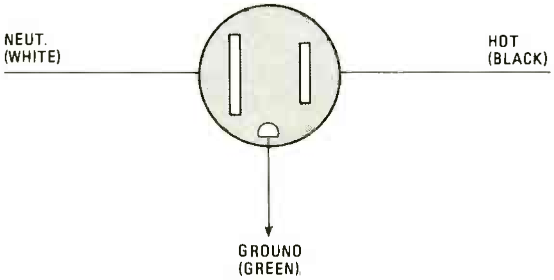


FIG. 1—WIRING FOR THE typical electrical outlet. Note that the outlet shows a polarized plug receptacle.

The typical outlet, shown in Figure 1, consists of three wires. A "hot" wire (black), a "neutral" wire (white) and a "ground" wire (green). When a power surge occurs, it could be impressed on either the black or white lines. The green or ground wire traditionally conducts all stray voltages safely to ground.

Typically, the protective devices we apply to our computers are built into the multi-outlet power strips

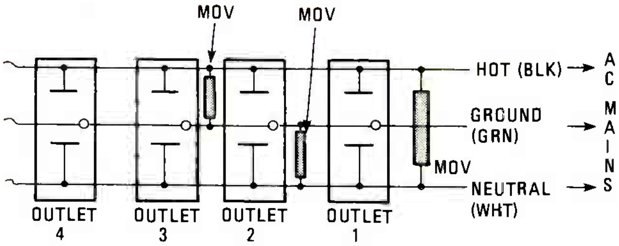


FIG. 2—A TYPICAL MOV-PROTECTED outlet strip. As many additional outlets as needed can be added to the circuit.

and resemble the circuit shown in Figure 2. Each line has what is called a MOV (Metal Oxide Varistor) for surge protection. These non-linear devices are voltage-dependent and divert potentially harmful overvoltage conditions. More simply, they "clamp" the voltage and hold it to a safe level.

Building protection

We're going to show how to protect one or two devices, rather than suggest that you buy a multiple outlet strip for surge protection along with filtering that you may not require for your new TV set.

We chose the number "two" because the normal wall outlet in your home is called a "duplex" outlet. There are two identical AC outlets wired in parallel. By protecting one, we also protect the other, giving us an extra benefit at no increase in cost.

Figure 3 shows how to do this. The three MOV

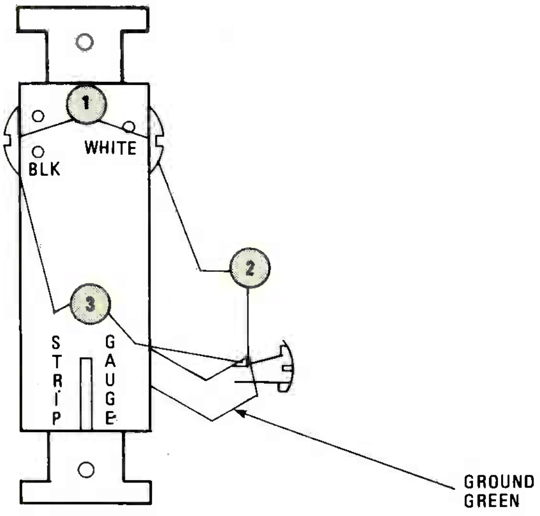


FIG. 3—WIRED RECEPTACLE (rear view) shows how MOV units are placed.

devices required are available from Radio Shack (MOV transient protector Part No. 276-568). They sell in packages for $1.69. You will also need some insulating tubing and some heat-shrinkable tubing.

First identify the fuse or circuit breaker controlling the outlet you plan to modify. To do this, plug a lamp into the outlet and turn the lamp on. Now proceed to unscrew the fuses or turn off the circuit breakers one at a time until the lamp goes out. If you're dealing with fuses, remove the fuse completely. Leave the circuit breaker in the OFF position.

Do **not** attempt to do this work with a "live" circuit!

Remove the screw holding the wall plate. place the screw aside and remove the plate. If it has become stuck in paint, you may have to pry it loose. Place the plate aside with the screw.

You will see two screws, one at the top, one at the bottom. These hold the outlet to the Gem box. Remove these screws and lift the switch out of the box.

Identify the following wires: The BLACK wire, the WHITE wire, the GREEN wire. In older homes, you may find the wire formed into a hook and located under a screw at either side of the outlet. More-modern outlets have the wire end slipped into a hole at the back of the outlet and held in place by screws on the sides. The GREEN or ground connection is usually connected to a single point at one end of the shell.

Loosen the screws as required, and connect one MOV device from the WHITE lead to the BLACK lead. Connect another from the BLACK lead to GROUND, the third MOV goes from the WHITE lead to ground. Examine your work carefully. If there is any exposed wire that might produce a short circuit, especially when the outlet is reinstalled in the gem box, cut a small piece of the insulated tubing and slip it over the exposed leads.

Carefully dress the MOV's against the outlet shell. Replace the outlet into the wall box, replace the upper and lower screws, then position the cover plate and replace the holding screw.

This completes the modification of the outlet for surge and transient protection. Now you can restore the electricity by turning the circuit breaker on or replacing the fuse.

You have provided two outlets with surge and transient protection for a total cost of less than $5.00, with the assurance that these transients and surges can be "clamped" within a stated response time of less than 35 nanoseconds—more than sufficient to save your valuable equipment.

You might wonder why, if surge protection at the individual outlet is such a good idea, we don't simply go to the fuse or circuit-breaker box and place the MOV's right there, and in that way protect all of the outlets in the home? The answer is simple. By doing that, you're fooling with the house's primary wiring, and depending on where you live, might require a building permit to do so. The consequences can be dire. Should you have a fire in your house, this type of do-it-yourself wiring addition can void your insurance.

No, you're better off to restrict yourself to the method we describe here, and add the MOV's—judiciously—at the individual outlets. We say "judiciously," because there's really no requirement to protect some devices against surges. If all you plug into an outlet is a simple lamp, why bother with surge protection? However, should the outlet be used for a TV receiver, stereo equipment, or anything else that might be worth protecting, by all means, this is the way to go.

COMPUTER AIDED DESIGN

A designer's dream come true.

HERB FRIEDMAN

■CAD, Computer Aided Design, covers everything from the complete design of a skyscraper hotel to the schematic for home-brewed electronic projects.

Using a PC

Theoretically, we could use conventional computer graphics to prepare schematics and flow charts, but that's the hard way to do things, for each line, symbol and alphanumeric character would involve a separate construction. We could probably do a lot better—and faster—with a pencil and paper. And even if we *did* the job with conventional computer graphics, a modification to what we create would take longer than redrawing the entire thing with the trusty old paper and pencil!

There are two kinds of low- to moderately-priced CAD programs specifically intended for electronics hobbyists and technicians. The most-common variety, usually priced in the range of $500 to $1000, are descended from conventional mainframe CAD systems and they generate a family of shapes such as rectangles, circles, triangles, trapezoids, etc. that one would normally use to design a building or a car or a kitchen sink. The shapes can be used for creating flow charts and even some electrical circuits.

The shapes are automatically created by the computer between two or three locations that the user pinpoints on the computer screen. Figure 1 shows how a CAD program might automatically create an assortment of shapes. For example Figure 1A shows how a rectangle is created by CAD. Using a joystick, mouse, or just the computer's arrow keys, the user positions the cursor where one corner of the rectangle should be and marks the location with a dot, by pressing the joystick's or mouse's *select* button. Next, the cursor is moved to the opposite corner of the rectangle. As the cursor moves, most CAD programs will create a phantom (flashing) rectangle anchored on the mark and the cursor. When the rectangle is in the desired shape and size, it is locked into position by pressing the *select* button.

The shape constructed on the screen between the mark and cursor depends on the selected mode. As shown in Figure 1B, if the user selects a circle mode, the computer will create a circle using the mark and cursor as the diameter. If, as shown in Figure 1C, the user selects a line mode, the computer will draw a straight line between the mark and the cursor. Triangles and trapezoids take an extra step or two, but the idea is the same.

If you need an unusual shape you simply create it using conventional shapes and lines. In Figure 2, the IC is simply a rectangle with short, straight lines appended for the terminals, while the OPAMP is similarly a triangle with lines for the terminals.

Making it viable

A logical question at this point, is "Since it can take a long time to create the symbol for a 14-point DIP IC what happens if you need 20 or 30 such symbols?" Most of the better quality conventional CAD systems have a *replicate* or *copy* function whereby the user can "pick up" a copy of a symbol by placing the cursor over the symbol and pressing the joystick or mouse-select button. The cursor is then positioned where a copy of the symbol is needed and it is literally dropped into the screen drawing by pressing the select button. The pickup and release can be repeated as often as needed, or the CAD program might require the user to indicate the total number of replications. Because different sizes of the same shapes or symbols are often needed, CAD software generally lets the user zoom in and out on individual symbols for enlargement or reduction during replication.

Just about anything is possible if you're willing to pay for it. For example, the cost of a digitizing pad equipped with a combination light and mechanical pen will buy you a library of *pick up* symbols that can be electronically lifted from the pad and then inserted in the screen.

While a symbol library usually adds substantial cost to a CAD program, it's actually the cost of the digitizing pad that makes it expensive. If the *pick-up* feature is eliminated—thereby eliminating the need for a digitizing pad—even a rock-bottom priced CAD system can have a library of symbols and alphanumeric characters.

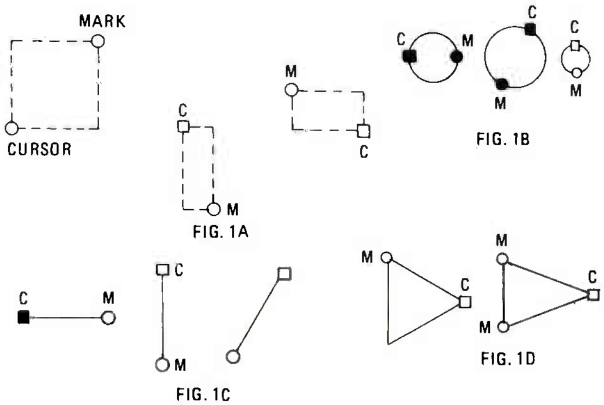
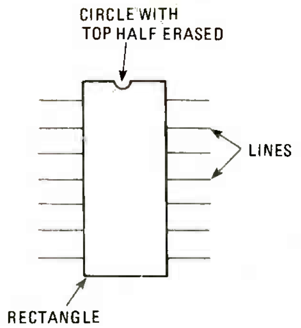


FIG. 1—HIGHER-COST CONVENTIONAL CAD systems automatically generate shapes and symbols between the user-selected marker and the cursor position. The shape automatically adjusts to the distance between the marker and cursor. In 1A, the system is set to generate rectangles. 1B is circles, 1C is straight lines and 1D is triangles.



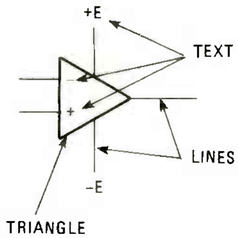


FIG. 2A
IC

FIG. 2B
OPAMP

FIG. 2—COMPONENTS CAN BE CREATED by using the computer's graphics function or by integrating pieces of auto-generated shapes. The IC in 2A started out as a generated rectangle, a circle provided the "notch" and the terminals are conventional lines. The OpAmp in 2B began as a triangle, the connections are lines and the labelling is generated by the CAD TEXT mode.

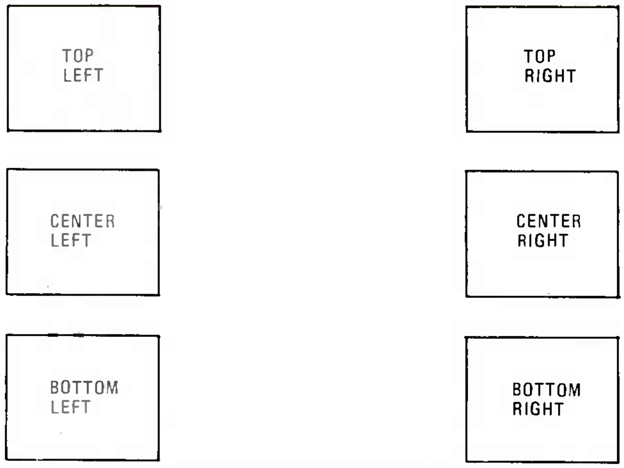


FIG. 4—ACTUAL COMPUTER WORKSPACE is divided into six screens which the printer reassembles. User selects as many screens as needed, decides how they are used.

Since a complete schematic or flow-chart might (and usually does) exceed the capacity of the screen, CAD programs generally permit the user to utilize several screens which are assembled into a unitized drawing when printed. If the number of screens exceed the capacity of the printer, provision is made for the print to be made in sections which can later be taped together.

If all you need is enough CAD power to generate schematics to store on a floppy disk for future review or easy-to-write upgrades and modifications, you can do it on a low-cost home computer using a conventional printer such as the Epson MX-80 (with Graftrax) for the printout. Usually, "drafting" software for home computers is not much better than a child's "computer art" program, but one low-cost program has

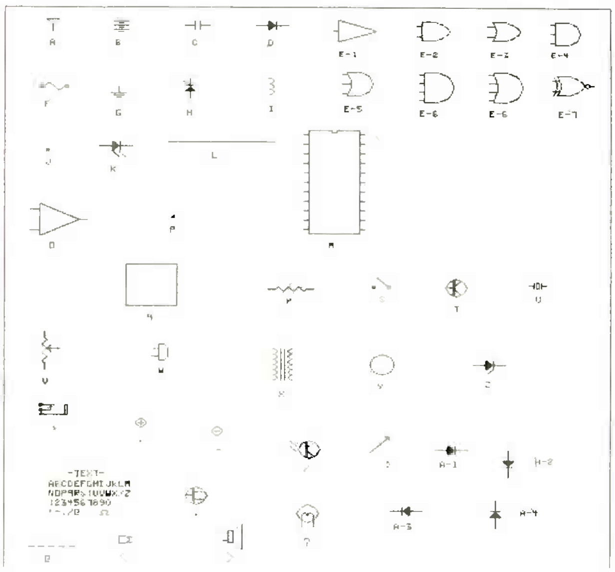


FIG. 3—THE COMPLETE LIBRARY of symbols and text (alphanumeric) for the Drafting Processor. Symbols are inserted at the cursor position pressing the indicated key. A "K" inserts the LED symbol, the "O" inserts an OpAmp, The "B" a battery.

enough "professional" features to enable a home computer to function as a CAD system for electronic technicians and hobbyists. It is in fact, good enough to serve as a trainer for those who want to dip their toes into electronic schematic design.

The CAD software is the Schematic Drafting Processor ($49.95, Spectrum Projects, Box 21272, Woodhaven, NY 11421) which requires a 64K Radio Shack Color Computer having at least one disk drive. The program is specifically designed to create electronic schematics primarily through the use of conventional symbols provided in the symbol library shown in Figure 3. Notice that each symbol has an associated keyboard character. Because a light pen isn't supported by the program a library symbol is called up at the cursor position by pressing the key specified for a particular symbol. For example, the "K" key will insert the LED symbol at the cursor. To permit precise positioning, each symbol can be rotated through 360 degrees in 90 degree increments. An erase function permits bits and pieces of library symbols to be pieced together. For example, the top of the circle can be sliced off to generate the half circle needed for the "bottom view" of a transistor. The IC symbol can be sliced, cut through, partially erased or expanded to create any IC package from 4 to 40 pin, or anything else. It takes a lot longer to generate symbols by erase and slice rather than by zoom, but it's a lot less costly.

Also note from Figure 3 that the alphanumerics as well as the omega symbol used to show resistance are also library symbols. When the computer is toggled into the TEXT mode, pressing a key inserts its corresponding alphanumeric character at the cursor position rather than a symbol, permitting you to label the various devices.

In addition to the 30 library symbols provided, the program allows the user to create ten additional symbols through a BASIC program, but doing so requires a considerable degree of programming skill.

Because screen size is limited, as shown in Figure 4, the total workspace is divided into six screens. Each screen display has a slight overlap with adjacent

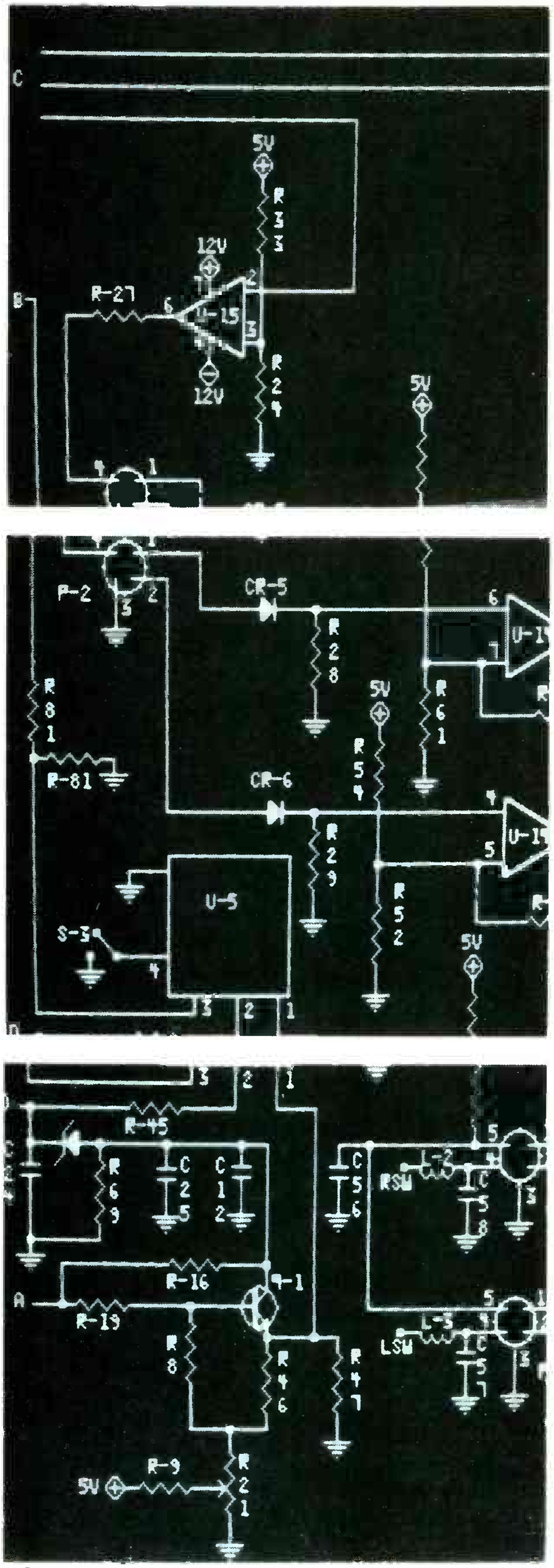


FIG. 5—PHOTOGRAPHS OF THE THREE LEFT SCREENS of an actual schematic. Note the overlap of each screen so drawing continuity can be maintained.

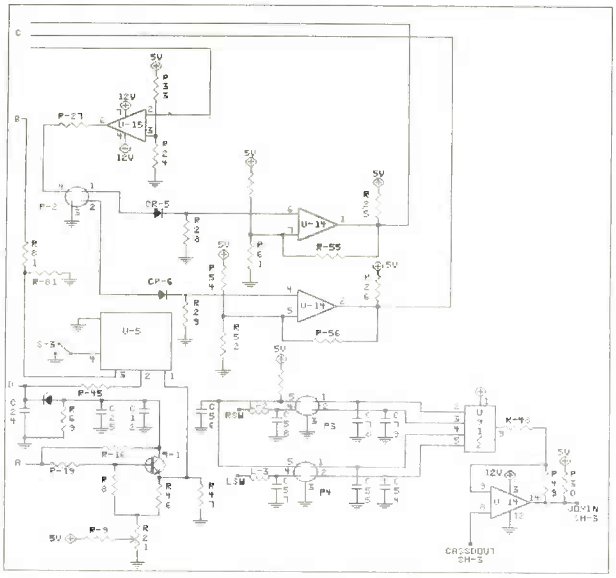


FIG. 6—THE SAMPLE SCHEMATIC—all six screens—as reassembled by a conventional Epson MX-80 dot-matrix printer. Note how components were rotated for proper orientation when inserted into the schematic.

screens so the user can continue registration from previously prepared screens. Like the more expensive CAD systems, all screens are combined into a unit drawing by the printer. Figures 5 and 6 show how this is done. Figures 5*a*, 5*b* and 5*c* are photographs of the actual screen display of the top left, center left and bottom left screens of a schematic that requires all six screens. The overlap area of each screen can easily be seen. Figure 6 is a printout of the entire schematic, all six screens. Note how the three left screens have been precision assembled by the program into the unit print. If the schematic required more area than that allowed by six screens it would have to be created in multiple units of six screens, and it would be necessary to tape together the unitized screen prints into a larger print because six screens is the maximum that can be printed as a single unit.

Unlike a printer/plotter print which is drawn by an inking (ruling) pen, the low-cost CAD prints are generated through the dot-addressable function of a conventional printer. Since the lines, symbols and characters in the print are created by individual dots the print's resolution is coarse, having no resemblance to the "ruled lines" of the professional plotter.

Ready to buy?

The thing to keep in mind when learning to use CAD software or a complete system is that it should make life easier than doing things by hand. Even the best CAD software is difficult for the technician to use if he doesn't have an adequate library of conventional symbols. Or, if you're into flow charts or block diagrams then automatic symbol construction, replicate and zoom of rectangles, circles and trapezoids is considerably more important than a library of symbols. Either way, CAD programs or systems should have features, functions and conveniences specifically intended for the preparation of schematics.

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COMPUTER PRODUCTS

continued from page 4

models *II*, *12*, and *16*. SemiDisk Systems has developed a new, high-capacity unit that stores up to 2 megabytes of information on a single card. Previously, the largest capacity available on a single card was 1 megabyte.

SemiDisk is priced as follows: 512K capacities: TRS-*80*, S-100, $995.00; QX-*10*, $799.00; IBM *PC*, *XT*, *AT* $945.00. Two-megabyte capacities: TRS-*80*, IBM *PC*, *XT*, *AT*, QX-*10*, $2499.00. S-100 is $2549.00.—*SemiDisk Systems*, PO Box GG, Beaverton, OR 97075.

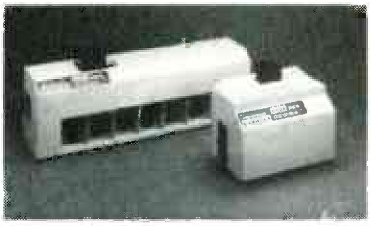
COMPUTER RECIPE SYSTEM, *A COOK™*, helps users to locate their own recipes through an easy-to-use indexing system. It allows the user to set up complete recipes of considerable size, and comes with a data base of 500 recipe references from five

CIRCLE 13 ON FREE INFORMATION CARD

best-selling cookbooks: *Joy of Cooking, M. Heater's New Book of Great Desserts, Mastering the Art of French Cooking Vol. 1, The New James Beard*, and *The New New York Times Cookbook*. The *A COOK™* diskette comes with an instruction booklet, and is priced at $39.95.—*East Hampton Industries, Inc.*, 66 Newtown Lane, East Hampton, NY 11937.

CERTIFIER, the *5000 series*, are microprcessor-based systems that feature Mountain Computer's automatic diskette autoloader and the ability to test high-coercivity media. Certifiers are used by floppy-diskette manufacturers and converters to test media quality, and by end users for incoming quality control.

Four models are available for certifying 3 ½" and 5 ¼" media. The six-bin models simultaneously perform up to



CIRCLE 14 ON FREE INFORMATION CARD

six media quality tests specified by the American National Standards Institute (ANSI): missing bit, extra bit, track average, amplitude, modulation, overwrite, and resolution. The two-bin certifiers perform the same ANSI tests. They are designed primarily for go/no-go incoming inspection of diskettes by large-volume users and original-equipment manufacturers.

The model *5250* six-bin, 5¼" certifier and the model *5253* six-bin 3½" certifier cost $17,915.00. The model *5150* two-bin 5¼" and model *5135* two-bin, 3½" certifier cost $13,995.00.—*Mountain Computer, Inc.*, 300 El Pueblo Road, Scotts Valley, CA.

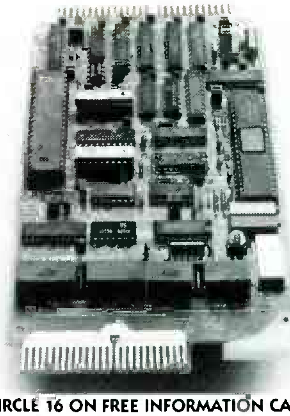
ELECTRONIC TYPEWRITER, the model *ZX-515* can be used independently as a typewriter, or, when interfaced with a computer, as a letter-quality printer; and, connected to an optional disk drive, the 40,000-character memory can be expanded to unlimited off-line storage.

CIRCLE 15 ON FREE INFORMATION CARD

Features of the model *ZX-515* include storage capacity for 26-page formats and 10-column layouts; global search and replace, as well as block move and text linking; four pitch modes: 10, 12, 15, or proportional spacing, and one-touch correction. The model *ZX-515* is priced at $1295.00.—*Sharp Electronics Corporation*, 10 Sharp Plaza, Paramus, NJ 07652.

CONTROLLER CARD, model *7388A*, offers fast memory access and data storage in double-density disk format, while addressing up to 1M of memory for use with 16-bit CPU's.

The model *7388* can interface with 8-bit systems based on Z80, 8085, 6800, and 6809 processors, addressing 64K of memory via DMA and decoding an 8-bit I/O address. The card also supports 8088-based systems with DMA acess to 1M of memory, and the ability to decode up to 10 bits of I/O address. It supports up to four floppy drives in any



CIRCLE 16 ON FREE INFORMATION CARD

format, and comes with a two-year warranty. It is priced at $395.00.—*Pro-Log Corporation*, 2411 Garden Road, Monterey, CA 93940.

PRINTER CONTROL PACKAGE, *Printworks*, lets users of IBM *PC* and compatible systems print wide documents, like spreadsheets, sidewise on standard-width paper. "Pivot Printing", which rotates text 90 degrees to print sidewise on a page, is one of the many features in this printer-control software package. Users are offered easy menu selection of many printer functions, including pitch, mode (boldface, expanded, condensed, etc.,) and font (typeface or style).

CIRCLE 17 ON FREE INFORMATION CARD

Fonts include script, Old English, foreign character sets, the complete IBM character set, and many more. A font editor lets users create additional characters or entire fonts, and even combine or alter existing fonts. *Printworks* is priced at $69.95.—*SoftStyle, Inc.*, 7192 Kalanianole Highway, Suite 205, Honolulu, HI 96825.

which the Linear Technology devices provide protection against.

- If the input falls more than 400 mV below ground, transistors in the input stage saturate and phase reversal could cause lock-up in servo systems. The LT1013/1014 devices include unique phase-reversal protection circuitry that prevents the output from reversing phase, even when the inputs are as low as −1.5 volts.
- If the input falls more than a diode-drop below ground, the device could be destroyed because essentially unlimited current could flow from the substrate ($-V_{SS}$) to the input terminal. The LT1013/1014 devices are protected against that type of failure by a 4000-ohm resistor in series with each op-amp input.

There is one circumstance in which the phase-reversal protection circuity will not work: when the output of another op-amp in the same package is driven hard into negative saturation. In the LT1013, either op-amp can disable the other's protection circuitry. In the LT1014, amplifiers A and D can affect each other, but amplifiers B and C are completely independent of the former. Similarly, amplifiers B and C can affect each other, but amplifiers A and D are completely independent of them.

An application

Figure 1 shows a liquid-flow meter designed around an LT1014 (or two LT1013's). The rate of flow through the pipe is determined from the temperature differential that occurs as liquid flows through a heated section of pipe. The ambient temperature of the liquid is measured by thermistor TI at the input end of the pipe. Thermistor T2 measures the temperature at the output end of the pipe. The temperature difference varies inversely with the rate of flow.

Op-amps IC1-*a* and IC1-*b* amplify the differential voltage developed by the thermistors, and op-amps IC1-*c* and IC1-*d* form a linear voltage-to-frequency converter. The output frequency ranges from zero (for a flow rate of zero) to 300 Hz (for a flow rate of 300 milliliters per minute). The rate of flow can be read directly on any audio-frequency meter.

The 15-ohm heater is a Dale Electronics 25-watt wirewound resistor, type HL-25. Thermistors T1 and T2 are YSI type 44201 thermistor networks available from Yellow Springs Instrument Co., Box 465, Yellow Springs, OH 45387. For additional information on the LT1013/1014 precision op-amps write to Linear Technology Corporation, 1630 McCarthy Blvd., Milpitas, CA 95035. **R-E**

ELECTRONICS IN MEDICINE

continued from page 64

broad categories, rigid and flexible. Here we will look at flexible endoscopes. Those use fiber optics to allow the viewing of regions deep inside the body.

Actually, modern technology allows physicians to do more than just look into those areas. It is possible to take tissue samples and even do surgery from a distance through a slender endoscope passed into the area of interest. That is possible because the structure of an endoscope contains several channels that run the full length of the instrument. Several of those channels carry the fiber optics. One fiber-optic channel is usually used for illumination (light sources used for endoscopes include tungsten projection lamps, lasers, and xenon and mercury arc lamps). A second channel can be used for viewing, taking photographs, and, if desired, making videotapes of procedures. Fiber-optic channels can also be used to transmit laser light for surgical cutting or for providing heat to close bleeding blood vessels. Other channels of the endoscope carry fluids for cleansing the area being viewed, suction for clearing away fluids and blood, and mechanical devices for cutting and taking biopsies (collecting samples of tissue).

Endoscopes of different diameters are used for different applications. Needle endoscopes, 1.7 millimeters in diameter, for instance, are used to examine the insides of knees and other joints. Similar instruments are useful in examining fetuses. Larger endoscopes are used in the gastrointestinal tract and other areas to find and treat tumors and bleeding blood vessels. Using such a device, foreign bodies can be found and removed, and other conditions can be diagnosed.

As we've seen, the field of medical optics has taken on new importance. Now, thanks to advances in such areas as fiber optics and lasers, it has become possible to visually examine and operate on many internal areas without resorting to conventional surgical techniques. And future advances are sure to make this area of medical electronics even more important and valuable in the coming years. **R-E**

SERVICE CLINIC

JACK DARR,
SERVICE EDITOR

A *vertical* line?

A COMMON PROBLEM IN TV SERVICING is collapse of the raster into a white horizontal line. It means that you have a problem in the vertical-sweep circuits. But much more unusual is the collapse of the raster into a white *vertical* line. Such an occurrence does not mean failure of the horizontal sweep circuit.

Let's see what it does mean. Looking at Fig. 1, the horizontal oscillator, driver, and output amplifier must all be working. Otherwise, there would be no high voltage. That's because the high voltage is derived from the horizontal output amplifier. And without high voltage, you would not be seeing a line of any kind at all.

Nevertheless, the horizontal sweep signal is not reaching the CRT. The first inclination is to blame either an open or shorted yoke. While either could be the cause, both are relatively rare occurrences. A much more likely cause is the presence of a problem *between* the horizontal output amplifier and the yoke.

FIG. 1

Some likely causes

The most common cause of our symptom is an open in one of the yoke leads. Those leads are often given a good yank when the chassis is removed from the cabinet, so they may come loose or even break.

If the problem is not in the yoke leads, use an oscilloscope to trace the signal from the output of the horizontal output amplifier to the yoke to find where the signal is disappearing.

Basically, the output of the horizontal output amplifier is coupled to the yoke in one of two ways: either directly or via a matching transformer. Tube sets always use matching transformers. On the other hand, only a few solid-state sets use those transformers; the rest use direct drive.

In direct drive, the emitter of the horizontal output transistor is tied directly to the yoke. My experience has been that the symptoms we've been looking at rarely occur in that type of set. That may be because, aside from the yoke leads, there is very little there that can fail without also affecting the high voltage.

As for sets that use a matching transformer, in general, I've found that horizontal problems in tube sets usually affect the high voltage, too. But our symptoms can and do occur in solid-state sets of that type. As such, the circuitry preceding the yoke should be checked carefully in those sets before turning to the yoke itself.

A shorted yoke

If doing the above does not lead to the cause of the problem, the only place left to turn is the yoke itself. In newer, solid-state sets the yokes are wound from relatively heavy wire. As such, shorts and opens are fairly rare. However, that does not mean that they do not happen. It just means that it takes an unusual occurrence.

In fact, I've only run into one instance of a shorted yoke in one of the newer sets. In that set, the raster had collapsed vertically into the familiar keystone pattern. The circuitry between the yoke and the horizontal amplifier was sound, so I turned to the yoke. Upon close examination, I found a splash of solder *inside* the yoke. (I never was able to figure out how it got there, but someone must have been an exceptionally sloppy solderer!) That solder was shorting several turns. Once the solder was scraped off, and the yoke was coated with insulating spray for "luck," the set was as good as new.

That just proves that anything is possible. **R-E**

SERVICE QUESTIONS

A HELPFUL HINT

Stuart Sjalund of London, Ontario would like to share one of his troubleshooting tips. He uses a 40-watt bulb in series with the horizontal output collector when he suspects an overload condition. He then lifts components until the bulb burns less brightly. He also checks SCR regulators by placing the bulb across the anode and cathode, again letting the intensity of the bulb act as his monitor. **R-E**

BENCH POWER SUPPLY

continued from page 57

−40 volts across D2 and D4, and +20 volts across C11 and C12. While you're at it, verify the presence of +20 volts on pin 7, and −20 volts at pin 4 of each op-amp. If everything checks out, remove power and insert the IC's. Be sure to orient pin 1 correctly.

Run wires from the transistors mounted on the rear panel (see Fig. 7) to the PC board. Finally, using Fig. 6, complete the point-to-point wiring between the board and the front- and rear-panel components. At this point, your power supply should appear similar to the prototype shown in Fig. 8.

Calibration

A DMM or VOM accurate to at least 4½ digits should be used to calibrate the precision sources. To obtain sufficient resolution, allow the supply to run for 10 minutes or more so that the temperature within the cabinet—and the output voltages of the precision sources—will stabilize. Adjust R44 and R51 so that their dials read 10.00 (i.e., their resistance should be exactly 10K ohms). Then adjust trimmer potentiometers R43 and R50 so that each output reads exactly 10.000 volts.

To get symmetrical outputs from the independent supplies, adjust R11 so that equal rotation of potentiometers R6 and R15 gives the same output voltage.

To adjust the dual-tracking source, turn potentiometer R24 to maximum resistance. Then adjust R29 for an output of exactly +15.000 volts, as measured at the $+V_T$ output. Then adjust R32 so that exactly −15.000 volts appears at the $-V_T$ output.

Substituting components

Some of the components specified in the Parts List may be difficult—if not impossible—to find. For example, you may have that problem with the 40-volt Zener diodes (D2 and D4). However, two 20-volt Zener diodes may be connected in series to achieve the same result.

The 2.7-volt Zener diodes (D8 and D10) may also be difficult to find. If they are, 3.3-volt units may be substituted (1N5226B). If doing so produces more than 1 mA from the constant-current sources, trimmer potentiometers R43 and R50 can be adjusted to compensate. The 6.8-volt reference diodes (D5 and D6) are not critical and may be either 1N957B, 1N5235B, or 1N4736A devices. The two 12-volt Zener diodes may be 1N963, 1N5242B, or 1N4742A units.

All electrolytic capacitors are polarized aluminum types, and radial-lead devices were used in the prototype to conserve space on the PC board.

All five cermet trimmer potentiometers used in the project are the ¾-inch long rectangular type.

Increasing power output

If you want to beef up the outputs of the non-precision supplies, you must increase the current capacity of the transformer, the output transistors, etc.

The transformer specified for this project has a rated output of 40-volts center-tapped at 300-ma. You may replace it with a unit having higher current capacity, but if you use a transformer with a higher voltage rating, be careful not to exceed the voltage rating of the op-amps and transistors.

The 2N3766 transistors (Q1 and Q5) may be replaced by 2N6057 devices; the latter have a maximum collector current of 12 amps. The 2N3740 transistors (Q3 and Q7) may be replaced by 2N6050 units, which also have a maximum of 12 amps. Both the 2N6050 and 2N6057 are housed in TO-3 cases and will require additional heat-sinking.

If you are using the metering circuit, the value of R52 might have to be increased, as well as the the rating of the current meter. **R-E**

MULTIPATH RECEPTION

continued from page 76

nal and the direct signal are amplified by the same gain factor and then rectified to produce DC voltages.

The comparator/control circuit compares the levels of the DC voltages derived from the two IF signals and immediately selects the antenna and tuner combination with the lowest DC voltage from the AM component of a multipath signal. The control circuit switches the input of the audio amplifier to the output of the tuner providing the better signal. Switching oc-

level, interference and distortion is first noticed as noise and hiss in the treble range. A further drop causes garbled sound and random dropouts. Mono signals have a higher high-frequency content than stereo signals, which results in better masking of noise and hiss.

Some car stereo makers use that fact to reduce multipath distortion. When multipath reception causes the incoming signal to fall below a given level, control circuits automatically switch the receiver from stereo to mono. In some sets, the switching from stereo to mono is rather abrupt and quite noticeable. In others, such as Pioneer's (5000 Airport Plaza Dr., Long Beach, CA 90815) receiver models *KE-*

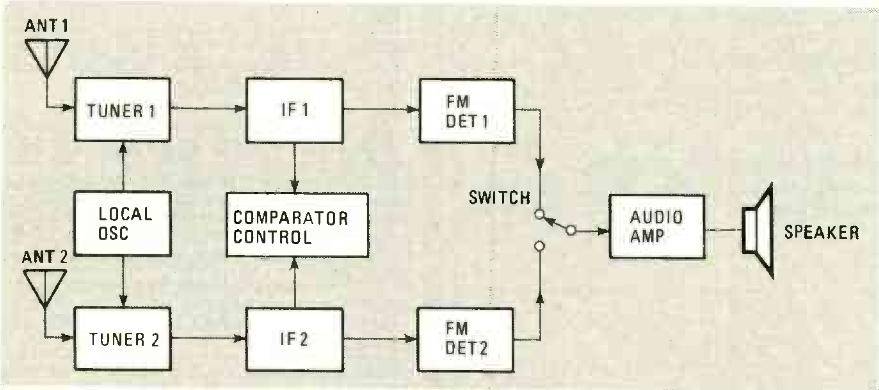


FIG. 8—BLOCK DIAGRAM of a stereo diversity reception stereo receiver. Note that it has two independent front ends.

FIG. 9—THE AUDIA *DXT-1000* diversity receiver from Clarion.

A630, *KE-A430*, and *KE-A330* (see Fig. 10) the transition from stereo to mono is achieved by a gradual blend of the left- and right-channel signals. As the FM signal gets stronger, the effect is gradually reversed.

In some receivers multipath distortion under weak-signal conditions is made less noticeable by rolling-off the high-fre-

FIG. 10—THE *KE-A330* stereo receiver from Pioneer automatically switches to mono when the signal strength drops below the level required for acceptable stereo reception.

curs as rapidly as necessary to ensure that the listener gets the signal with the least interference and distortion.

Other manufacturers use different techniques to reduce multipath distortion in automotive FM receivers. One such technique makes use of the fact that, for a given signal strength, a stereo FM signal is inherently noisier than a mono one. For adequate reception, a receiver requires a signal that is above a given threshold level. As the signal drops toward that

quency response when the incoming signal does not have enough treble content to over-ride hiss and noise. Usually that is done by feeding the recovered audio signal through a highpass filter and rectifier to a logarithmic amplifier that develops a DC voltage that is proportional to the high-frequency content of the signal. That DC voltage controls the bandwidth and roll-off of a variable highpass filter—cutting the high-frequency response so noise and hiss are eliminated. **R-E**

IC TESTER

continued from page 82

unison. More than likely, the circuit will tie pin 12 directly to signal ground. In that case, there is no easy way to get the two devices synchronized, and the comparison test will not work.

Testing IC's

To test out-of-circuit ICs:

- Connect power from external source
- Connect a grounded shorting plug to socket A
- Place all IC switches in the OUT position.

Select the appropriate IC card and insert it into the IC analyzer. Then insert the IC in the right-hand B socket (SO5). Use short jumpers of 22-gauge solid wire to make power and ground connections from the solderless connector to one of the B sockets.

The inputs can be tied low by putting the switches to the IN position. Do not switch the outputs, power, or ground pins. The pulser can be connected at the B socket, and should be used to test clocked logic. The pulse generator pushbutton is not debounced, so occasionally a double output pulse may result. **R-E**

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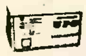

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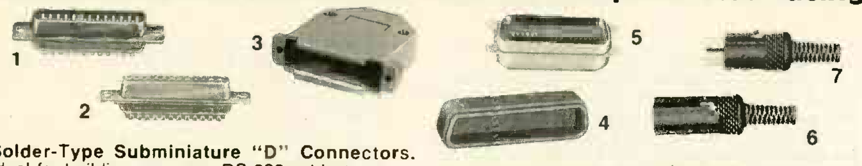

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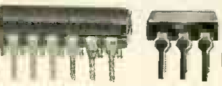

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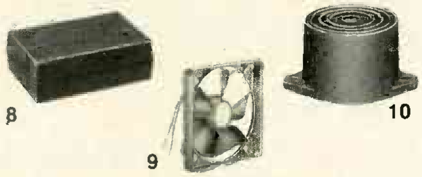

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*14-Pin DIP, others TO-220 case

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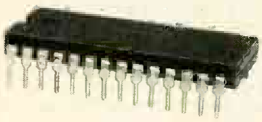

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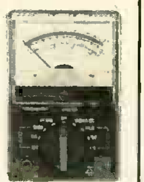

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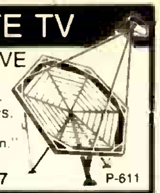

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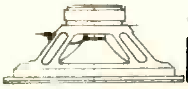

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74LS28	.34	74LS161	.64	74LS366	.48
74LS30	.24	74LS162	.68	74LS367	.44
74LS32	.28	74LS163	.64	74LS368	.44
74LS33	.54	74LS164	.68	74LS373	1.35
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74LS48	.74	74LS173	.68	74LS386	.44
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74LS92	.54	74LS242	.98	74LS683	3.15
74LS93	.54	74LS243	.98	74LS684	3.15
74LS95	.74	74LS244	1.25	74LS685	3.15
74LS96	.88	74LS245	1.45	74LS688	2.35
74LS107	.38	74LS247	.74	74LS689	3.15
74LS109	.38	74LS248	.98	74LS783	23.95
74LS112	.38	74LS249	.98	81LS95	1.45
74LS113	.38	74LS251	.58	81LS96	1.45
74LS114	.38	74LS253	.58	81LS97	1.45
74LS122	.44	74LS257	.58	81LS98	1.45
74LS123	.78	74LS258	.58	25LS2521	2.75
74LS124	2.85	74LS259	2.70	25LS2569	4.20

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6500

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6551	9.90

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6520A	5.90
6522A	9.90
6532A	10.90
6545A	12.90
6551A	10.90

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65028	7.90

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6800	2.90
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6808	12.90
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6809	8.90
6810	2.90
6820	4.30
6821	2.90
6828	13.90
6840	11.90
6843	33.90
6844	24.90
6845	11.90
6847	10.90
6850	2.90
6852	5.90
6860	7.90
6662	10.90
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6880	1.90
6883	21.90

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68B02	11.90
68809	11.90
68B09E	11.90
68B10	5.90
68B21	5.90
68B40	18.90
68845	18.90
68850	5.90

68000

68000-8	34.90
68047	23.90
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8039	5.90	8255	4.45
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		8289	44.90
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8100

8131	2.90
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Z-80

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6802	4.50	8251	4.40
6803L	8.00	8253	6.00
6809	8.00	8255A-5	5.00
6810	4.00	8257	6.00
6821	2.75	8259	6.00
6845	8.00	8272A	14.00
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3.579	10.000
4.000	18.000
5.000	18.432
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TL062CP	.95	LM384	1.60	LM1391	1.00
TL064CN	1.50	LM386	1.00	1456	.80
TL072	1.25	LM387	1.25	1458	.50
TL082	.90	LM393	.75	LM1808	1.75
TL084	1.50	LF398A	3.00	AD2700LD	4.95
LM201	.75	LM555	.34	LM2901	.95
LM301/748	.35	LM556	.65	CA3018	1.95
LM307	.45	558	1.75	CA3078AT	1.50
LM308	.65	564	2.50	CA3080	1.00
LM310	1.10	565	.90	CA3089E	1.75
LM311	.60	566	1.25	CA3094	1.30
LM318	1.25	567	.85	CA3130	1.00
LM319	1.30	NE592	.95	CA3140	1.00
LM324	.55	709CH	.80	CA3822	.75
LM339	.90	LM710	.60	LM3900	.50
LM348	.90	733	.95	LM3909	.80
LF351	.60	741CV	.35	4136	.85
LF353	.90	747	.50	N5596A	1.50
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14 PIN	.15	24 PIN	.25
16 PIN	.18	28 PIN	.35
18 PIN	.20	40 PIN	.40
20 PIN	.25		

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14 PIN	— .45
16 PIN	— .50
18 PIN	— .65
20 PIN	— .90
24 PIN	— 1.10
28 PIN	— 1.25
40 PIN	— 1.80

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EPOXY GLASS VECTOR BOARD

1/16" thick with 1/10" spacing
4½" x 6½" $2.40

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100	.35	.40	1.40	
200	.40	.50	1.80	
400	.60	.70	2.40	12.00
600	.80	1.00	3.60	15.00

TRIAC's

PRV	1A	10A	25A
100	.35	.60	1.40
200	.50	.80	1.90
400	.70	1.00	2.60
600	1.00	1.20	3.60

C/MOS

74C00	.35	74C915	1.10	4027	.45	4076	.80
74C02	.35	74C921	3.50	4028	.65	4077	.50
74C04	.35	4001	.25	4029	.75	4081	.28
74C10	.35	4002	.25	4030	.40	4082	.30
74C14	.55	4006	.85	4034	1.75	4093	.45
74C20	.35	4007	.30	4035	.85	4099	1.75
74C32	.35	4008	.90	4040	.75	4501	.95
74C42	1.20	4009	.40	4041	.75	4503	.65
74C74	.80	4010	.45	4042	.65	4506	.75
74C76	.60	4011	.30	4043	.85	4510	1.20
74C83	1.20	4012	.30	4044	.80	4511	.85
74C85	1.25	4013	.35	4046	.85	4512	.85
74C86	.40	4014	.75	4047	.95	4514	1.20
74C93	1.00	4015	.35	4049	.35	4515	1.60
74C154	3.00	4016	.35	4050	.35	4516	1.50
74C157	1.70	4017	.75	4051	.75	4518	.85
74C161	1.10	4018	.75	4052	1.00	4520	.80
74C174	1.10	4019	.40	4053	.75	4528	1.10
74C175	1.10	4020	.75	4060	.70	4529	1.40
74C192	1.40	4021	.75	4066	.40	4538	1.50
74C193	1.40	4022	.75	4068	.40	4539	1.50
74C245	1.75	4023	.28	4069	.28	4541B	1.75
74C901	.40	4024	.65	4070	.35	4553	1.75
74C903	.80	4025	.30	4071	.28	4583	.90
74C907	.90	4026	1.25	4072	.30	4586	.75

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74S00	.30	74S74	.50	74S163	1.75
74S02	.35	74S85	1.25	74S165	1.50
74S03	.35	74S86	.50	74S174	.90
74S04	.35	74S89	2.00	74S175	.90
74S05	.35	74S112	.50	74S181	3.00
74S08	.35	74S113	.60	74S182	2.00
74S09	.45	74S124	2.20	74S189	1.60
74S10	.35	74S133	.45	74S194	1.30
74S11	.35	74S135	.85	74S195	1.30
74S15	.35	74S138	.80	74S241	2.00
74S20	.35	74S139	.80	74S244	1.25
74S30	.35	74S151	.90	74S251	1.20
74S32	.40	74S153	.95	74S257	.90
74S40	.40	74S157	.90	74S260	.75
74S42	.85	74S158	.90	74S373	2.00
74S51	.35	74S161	1.75	74S374	2.00

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400	1.00	1.65	3.30
600	1.30	1.90	4.40

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200	.06	.17	.50	1.30	7.00	9.00
400	.09	.25	.65	1.50	10.00	12.00
600	.11	.30	.80	2.00	13.00	15.00
800	.13	.35	1.00	2.50	16.00	18.00
1000	.20	.45	1.25	3.00	20.00	26.00

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78M5, 12 or 15	$ .40		
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1UF 20V	5/$1.00	47UF 20V	$ .85
2.2UF 20V	5/$1.00	68UF 16V	$1.00
3.3UF 20V	4/$1.00	200UF 20V	$1.75
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10UF 20V	— $ .40		
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TIP 31B NPN Si TO-220	$ .40
TIP 32B PNP Si TO-220	$ .40
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TIP 121 PNP Si U84	$ .60
TIP 141 NPN Si U97	$1.00
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BU205	$1.75
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7401	.20	7483	.50	74170	1.50
7402	.20	7485	.55	74173	.75
7403	.20	7486	.35	74174	.85
7404	.20	7489	1.90	74175	.85
7405	.25	7490	.55	74176	.75
7406	.27	7491	.50	74177	.65
7407	.27	7492	.50	74180	1.90
7408	.25	7493	.35	74181	2.00
7409	.20	7494	.60	74182	.90
7410	.20	7496	.55	74184	1.50
7411	.25	7496	.60	74190	.80
7412	.25	74107	.30	74191	.80
7413	.35	74116	1.20	74192	.75
7414	.45	74121	.30	74193	.75
7416	.25	74122	.45	74194	.80
7417	.25	74123	.45	74195	.80
7420	.20	74125	.45	74196	.75
7425	.27	74126	.45	74197	.80
7426	.30	74145	.60	74199	1.25
7427	.27	74147	1.20	74221	1.25
7430	.20	74148	1.20	74273	1.00
7432	.27	74150	1.35	74279	.70
7437	.27	74151	.55	74298	.60
7438	.29	74153	.55	74365	.65
7440	.20	74154	1.25	74367	.65
7442	.45	74155	.75	74390	.90
7445	.65	74157	.55	75325	1.50
7447	.70	74158	.60	75492	1.00
7448	.70	74160	.85	9601	1.00
7450	.20	74161	.65	9602	.90
7472	.35	74162	.65	8T26	1.10
7473	.35	74163	.65	8T28	1.10
7474	.32	74164	.85	8T97	1.10
7475	.45	74165	.85	8T98	1.10
7476	.35				

74LS SERIES

74LS00	.32	74LS107	.35	74LS241	.95
74LS01	.25	74LS109	.35	74LS242	.90
74LS02	.25	74LS112	.35	74LS243	.90
74LS03	.25	74LS113	.35	74LS244	1.25
74LS04	.25	74LS114	.35	74LS245	1.40
74LS05	.25	74LS123	.75	74LS246	1.40
74LS08	.25	74LS125	.45	74LS247	.75
74LS09	.25	74LS126	.45	74LS248	1.00
74LS10	.25	74LS132	.55	74LS251	.55
74LS11	.30	74LS136	.35	74LS253	.55
74LS12	.30	74LS137	.90	74LS257	.55
74LS13	.40	74LS138	.50	74LS258	.55
74LS14	.50	74LS139	.50	74LS259	1.75
74LS15	.25	74LS147	2.20	74LS260	.55
74LS20	.25	74LS151	.55	74LS266	.55
74LS21	.25	74LS153	.55	74LS273	1.50
74LS22	.25	74LS155	.65	74LS279	.45
74LS26	.25	74LS156	.65	74LS280	1.70
74LS27	.25	74LS157	.65	74LS283	.65
74LS28	.30	74LS160	.65	74LS290	.80
74LS30	.25	74LS161	.65	74LS293	.80
74LS32	.25	74LS162	.70	74LS298	.90
74LS37	.35	74LS163	.65	74LS320	2.00
74LS38	.35	74LS164	.65	74LS323	3.50
74LS40	.30	74LS165	.65	74LS365	.45
74LS42	.50	74LS166	1.75	74LS366	.45
74LS47	.75	74LS169	1.50	74LS367	.45
74LS48	.75	74LS170	1.30	74LS368	.45
74LS51	.30	74LS173	.65	74LS373	1.30
74LS54	.30	74LS174	.50	74LS374	1.30
74LS73	.35	74LS175	.50	74LS377	1.30
74LS74	.35	74LS181	2.00	74LS386	.45
74LS75	.35	74LS190	.90	74LS390	1.10
74LS76	.35	74LS191	.80	74LS393	1.00
74LS83	.60	74LS192	.75	74LS398	2.50
74LS85	.60	74LS193	.75	74LS446	2.00
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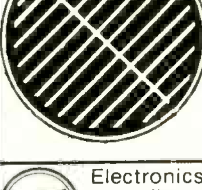

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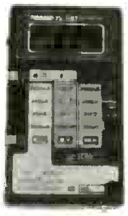

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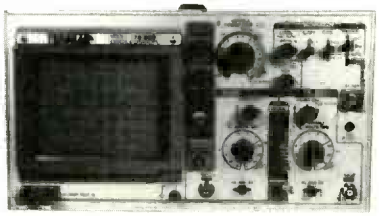

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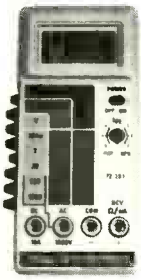

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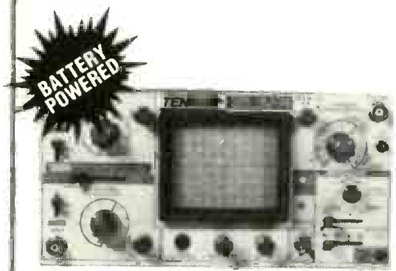

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■ Two High Quality 10:1 Probes included ■ Backed by our 2-year limited! warranty ■ Internal rechargeable batteries provide 2 hours of continuous operation without the need for any outside power source. ■ For specifications see MCM Catalog #10, page 121

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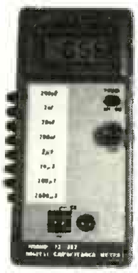

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■ Measures capacitors from 0.1pF to 1999mFd ■ Accuracy 0.5% typical ■ Fuse protected ■ Checks capacitors in and out of circuit ■ Backed by our 1-year limited warranty ■ For more specifications see MCM catalog #10, page 122

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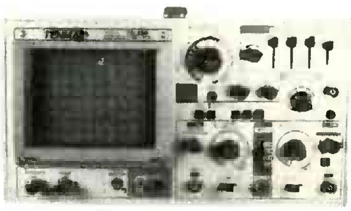

TENMA 35 MHZ DUAL TRACE OSCILLOSCOPE

■ Two High Quality 10:1 probes included ■ Backed by our 2-year limited warranty ■ For specifications see MCM catalog #10, page 121

#72-330 $569.00

TENMA LOGIC PROBE WITH MEMORY

■ Recognizes high, intermediate, or low levels, pulsing modes, open circuit ■ Compatible with DTL/TTL/HTL/CMOS IC ■ Detects pulses as short as 50 nanoseconds

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■ Cross needle meter: Displays voltage, current, and power simultaneously ■ Over current protection ■ Output voltage: DC 9-15V variable ■ Output current 30A one minute on three minutes off, 22A continuous ■ Backed by our 2-year limited warranty ■ For specifications see MCM Catalog #10, page 123

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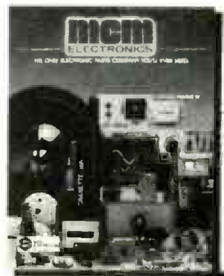

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74LSXX	.25	74ALSXX	.35
74LS1XX	.35	74ALS1XX	.45
74LS2XX	.50	74ALS2XX	.60
74LS3XX	.50	74ALS3XX	.60

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74F1XX	.45
74F2XX	.60
74F3XX	.60

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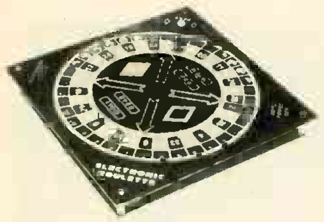
TY-47 SUPERIOR ELECTRONIC ROULETTE

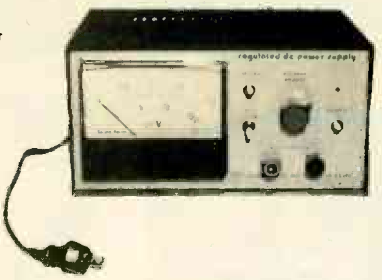


This roulette employs three CMOS IC to drive thirty-six LEDS. It includes sound, effect circuit and automatic power on/off switch. Its feature can be comparable to real Roulette. It is simple in construction and easy to build.

- Deluxe colour face panel is free of charge.

Kit.................... $16.92

TR-100 0-15V 2 AMP. REGULATED POWER SUPPLY KIT



This is a professional power supply kit. Output voltage adjustable from 0-15VDC. Output current also can be limited to two range sections such as 200mA and 2A. An elaborated protection system also designed to give out a beeping sound and a flashing LED warning will appear when output was over loaded or short circuited. High stability and reliability resulting from employing a high quality voltage regulator IC. The front panel of the power supply is well designed with output terminals, on/off switch, voltage adjusting control, jumbo size meter for reading both AMPs and VOLTs. Also with a volt/amp switch as well as current limit select switch. Kit comes with ratined metal case, silver color with sand brushed front panel, all electronic parts, p.c. board, 3" jumbo size meter transformer, circuit diagram and instructions.

Kit.................... $59.50 Assembled with tested.................... $69.50

TY-23B COLOR LIGHT CONTROLLER

As a result of the advanced technology, this unit can control various colorful light bulbs, the visual effect of which is most suitable in places like at home party, disco, electronic game centre and also in lightings for advertisement. Total output power is 3000W (1000W/Ch.) which means that it can control 30 pieces of 100W or 600 pieces of 5W color light which is enough for most usages.

FEATURE:

(1) "Music" mode.
Audio signal is devided into high, middle and low frequency to drive 3 groups of light, it has seperate sensitive controller.

(2) "Chasing" mode.
Electronic circuit automatically controls 3 groups of color light in sequential ON and OFF; also it has a speed controller. Build one of these light controller today and enjoy watching your music. Great for school projects! all electronic parts, metal case, predrilled p.c. board and instructions are come with the kit.

Kit.................... $65.00 Assembled with tested....... $75.00

SM-100 150MC UNIVERSAL DIGITAL FREQUENCY COUNTER

SM-100 is an accurate, easy-operated digital frequency counter. Few pieces of advanced, high technical LSI integrated circuit are used, thus, circuit structure is reliable. SM-100 can give you up to 8 digits of resolution for a wide frequency range of 10Hz to 150MHz. Besides, a memorize system is available, the last input digits can be held on the panel, as compare to the other or even observation.

Input sensitivity: KHz range 10Hz – 10MHz 50mVrms
MHz range 1MHz – 150MHz 40mVrms

Response time: 0.2 sec
Hold: Hold the last input signal
Power supply: DC6V Battery or DC9V 250MA Adaptor
Assembled with tested....... $99.00

TA-2400A ELECTRONIC ECHO AND REVERBERATION AMPLIFIER

This unit combines the most advenced computer V.L.S.I. technique with high quality Japan made component, so it has the following **FEATURES.**
It can generate various refletion and reverberation effect such as that in valley and music hall. It has a 3 section effect control which includes reverberation control, delay control and depth control.
All kinds of infield sound effect can be obtained by skilful use of this control. It has LED display to show reflection and reverberation.
Assembled with tested $99.85

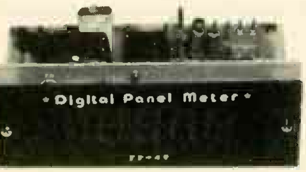
TA-323A HIGH QUALITY 30W + 30W STEREO AMPLIFIER

This amplifier employs newly designed symmetrical output circuit which uses high efficiency Darlington transistor, so it has good efficiency and excellent characteristic. The driver transistor will never overheat. It is easy to build and no alignment is required

Specifications:
Power Output: 30W + 30W (8 ohm)
Total Harmonic distortion: Less than 0.1% between 100Hz & 10KHz
Pre amplifier:
Input Sensitivity: 3mV at 47K RIAA or Mic. Equalised
130mV at 47K TAPE, TUNER
S/N Ratio: 80dB
Output Impedance: 4-8 ohm
Power Voltage: DC 30-50V
AV 22 36V x 2 3A
Kit.................... $24.60

The Best Kit for Hi-Fi Beginner!

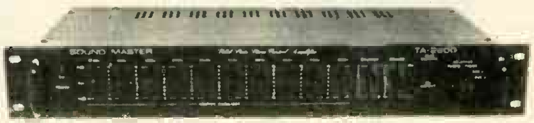
SM-48 4½ HI-PRECISION D. P. M.



- 4½ digit, each with a large red LED indication of 0.6" Auto-flash whenever it is overloaded.
- Range: DC current ± 1uA – ± 20A
  DC voltage ± 1mV – ± 2000V
- Stability: DC ± 0.025% ± 2 digit
- Power supply. DC 5–6V 200mA
- Size: 4 5/16" (W) x 3 1/4" (D) x 1 3/4" (H)
- Various functions are avaliable: output terminal of BCD, BUSY, STROBE etc., which are suitable for working with microcomputer.
- Temperature Compensated Regulator of 100ppm/ °C is employed as to upset this unit's stability.
- The memory system can hold the latest reading, for the convenence of comparison and observation.

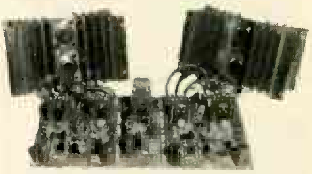
Kit.................... $38.00 Assembled with tested $43.00

TA-2500 HIGH QUALITY MULTIPURPOSE PRE-AMPLIFIER



This specially designed pre-amplifier includes a professional GRAPH EQUALIZER TONE control system and has a gain of ± 12dB. Frequency response extends from 5Hz to 20KHz, so even in bad listening condition it can improve well. It can accept input from variuos magnetic cartridge, record deck and tuner, its output can be connected to all kinds of power amplifier!
Assembled with tested $90.00

TA-802 80W + 80W PURE DC STEREO POWER AMPLIFIER



- This power amplifier employs pure DC mirror circuit and several current stabilizers, so it has high stability. No AC bypass capacitor is included in feedback network, so frequency response is extended to DC and there is no phase distortion, it can reproduce high level bass faithfully.
- It uses FET differential input to improve S/N ratio and input impedance.
- It is compatible with all kinds of preamplifier.
- It has a multipurpose protection system, including high sensitive DC output protection circuit, high speed output short-circuit, overload protection, and an automatic temperature control system. It can protect the loudspeakers and amplifier against damage.

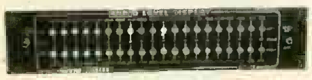
Kit.................... $39.95

TA-3000 STEREO SIMULATOR

You can own a **STEREO TV from today!** This simulator is a special design of using the most advanceable monopolised L.S.I. It produces a superior analog sterao effect since the L.S.I. is equalled to 60 pcs. of LOW NOISE FET & TRANSISTOR. The simulator can even help you to promote your television from a normal one to a special one with a Hi-Fi STEREO functin. Our simulator is also applicable to any other 'mono sources' in converting it to ANALOG STEREO. Undoubtedly, it is the most advanced equipment for every family, while it should contribute to your listening pleasure.

Specifications:
Frequency Response: 10Hz-30KHz
Signal-to-noise ratio: 60dB (L.H.C.) 56dB (R.H.C.)
Distortion (Both ch.): 0.1%
Input Sources: High Input Impedance: AM tuner, Mono cassette Low Impedance: Radio, TV, VCR
Power Consumption: 6VA 110V
Assembled with tested.................... $30.00

TY-45 20 STEPS BAR/DOT AUDIO-LEVEL DISPLAY KIT



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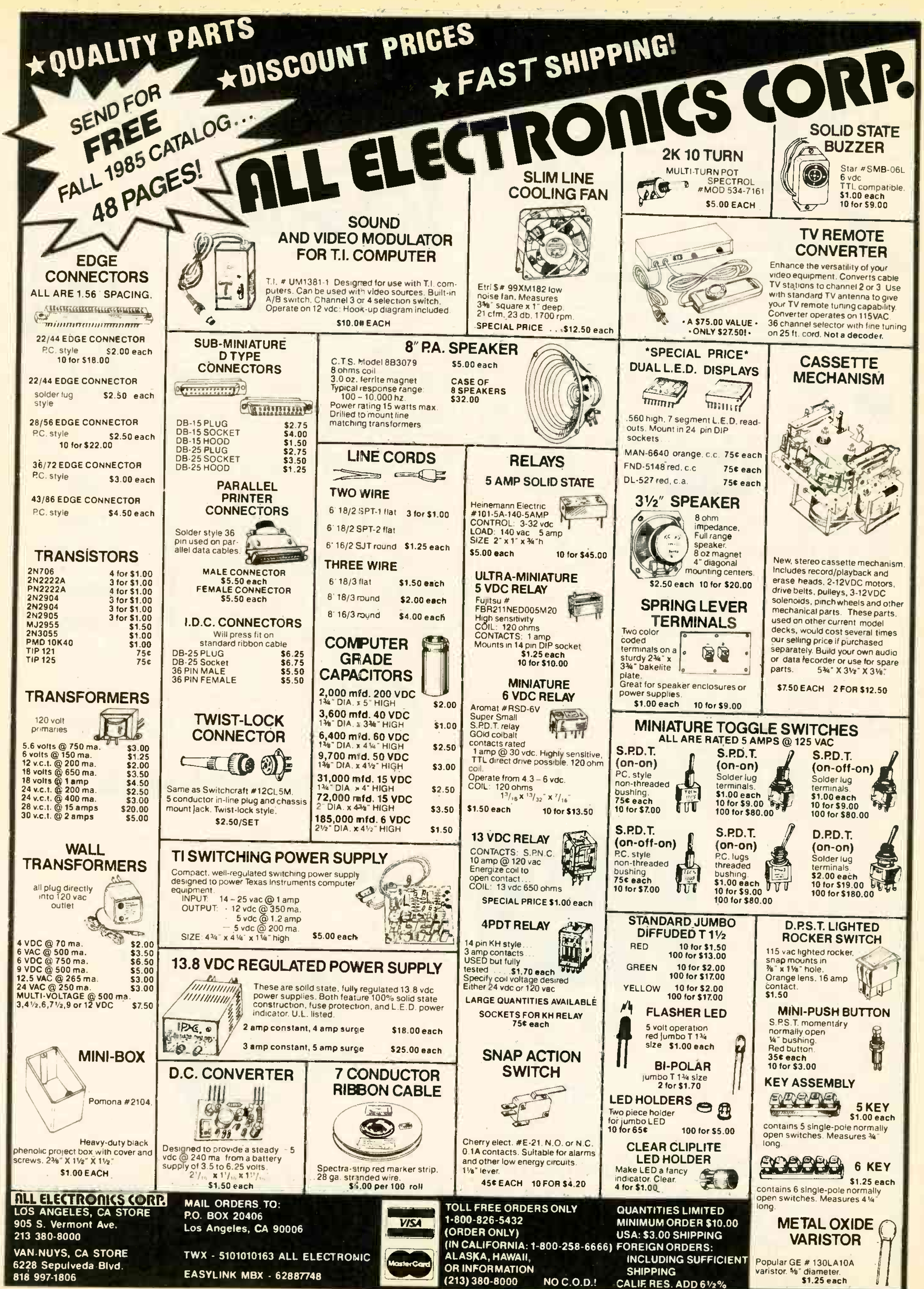

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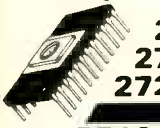

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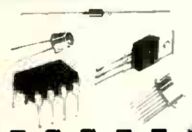

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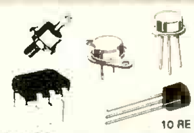

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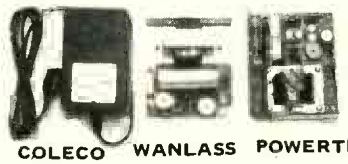

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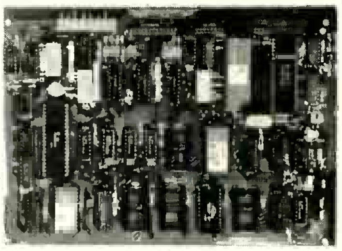

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4002	.22	4030	.39	4066	.39	4507	1.10		
4006	.79	4031	3.25	4069	.28	4508	1.90		
4007	.22	4032	2.15	4070	.35	4510	.79		
4008	.95	4034	1.91	4071	.28	4511	.79		
4009	.39	4035	.79	4072	.28	4512	.79		
4010	.39	4037	1.95	4073	.28	4514	1.18		
4011	.24	4040	.75	4075	.28	4515	1.79		
4012	.24	4041	.75	4076	.75	4518	1.19		
4013	.35	4042	.65	4077	.35	4518	.85		
4014	.75	4043	.85	4078	.35	4520	.75		
4015	.39	4044	.69	4081	.29	4555	.95		
4016	.35	4046	.80	4082	.29	4556	.95		
4017	.65	4047	.89	4085	.95	4566	1.35		
4018	.79	4048	.99	4086	.95	80C95	1.50		
4019	.39	4049	.35	4093	.45	80C97	.49		
4020	.69	4050	.34	4094	2.95	MC14408	12.95		
4021	.69	4051	.75	4098	1.90	MC14409	12.95		
4022	.69	4052	.75	4099	1.85	MC14410	9.95		
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LM305H	.95	LM710	.68	MC4024	3.75
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LM307N	.40	LM715	3.95	RC4131	3.75
LM308CN	.65	LM723N	.55	RC4136	1.19
LM310CN	1.65	LM723H	.55	RC4151	3.75
LM311CN	.62	LM733	.98	CA3023	2.75
LM312H	1.75	LM739	1.85	CA3039	1.25
LM318CN	1.45	LM741CN	.33	CA3046	1.25
LM318H	1.55	LM741H	.40	CA3059	2.85
LM319N	1.19	LM741N	.29	CA3060	2.85
LM320 (see VRs)		LM747	.65	CA3065	1.69
LM324N	.55	LM748	.55	CA3080	1.10
LM339N	.95	LM1014	1.15	CA3081	1.60
LM340 (see VRs)		LM1303	1.90	CA3082	1.60
LM348N	.95	LM1310	1.45	CA3083	1.55
LM358CN	.65	MC1330	1.65	CA3086	.80
LM359	1.75	MC1349	1.65	CA3089	2.95
LM360N	2.95	MC1350	1.15	CA3096	3.45
LM370N	4.95	MC1358	1.65	CA3130	1.29
LM373N	3.95	MC1372	6.75	CA3140	1.15
LM376N	3.75	LM1414	1.55	CA3146	1.79
LM377N	1.90	LM1558H	2.95	CA3160	1.49
LM380CN	.85	LM1800	2.35	LM13080	1.25
LM380N	1.05	LM1812	8.10	LM13600	1.45
LM381N	1.59	LM1830	3.40	LM13700	1.45
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LM383N	1.95	LM1872	5.45	LF351	.60
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LM392N	.69	ULN2003	1.49	TL071CP	.79
LM723N	.48	XR2206	3.75	TL072CP	1.35
LM723H	.55	XR2207	2.90	TL074CN	1.90
NE531	2.85	XR2208	2.90	TL081CP	.59
NE555	.35	XR2211	3.75	TL084CN	1.90
NE556	.65	LM2877P	2.00	TL494	4.10
NE558	1.49	LM2878P	2.25	TL496	1.65
NE561	23.50	LM2900	.83	TL497	3.20
NE564	2.85	LM2901	.99	MC3423	1.49
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7402	.18	7448	.68	74126	.44	74179	1.34		
7403	.18	7450	.19	74128	.49	74180	.75		
7404	.18	7451	.19	74132	.45	74181	1.75		
7405	.23	7453	.19	74136	.75	74182	1.15		
7406	.49	7454	.19	74141	.65	74184	2.25		
7407	.49	7459	.25	74142	2.95	74185	2.25		
7408	.24	7460	.37	74143	3.70	74190	.67		
7409	.19	7470	.29	74144	2.95	74191	.67		
7410	.19	7472	.29	74145	.59	74192	.67		
7411	.24	7473	.33	74147	1.49	74193	.67		
7412	.38	7474	.34	74148	1.19	74194	.67		
7413	.34	7475	.38	74150	1.09	74195	.67		
7414	.49	7476	.34	74151	.55	74196	.75		
7416	.49	7479	4.60	74152	.67	74197	.86		
7417	.49	7480	.69	74153	.53	74198	1.15		
7420	.19	7482	.95	74154	1.19	74199	1.15		
7421	.35	7483	.45	74155	.69	74221	1.19		
7422	.45	7485	.55	74156	.69	74251	.75		
7423	.58	7486	.35	74157	.59	74273	1.65		
7425	.29	7489	1.95	74158	1.65	74276	1.89		
7426	.29	7490	.35	74159	1.58	74279	.75		
7427	.25	7491	.65	74160	.79	74283	1.40		
7428	.55	7492	.45	74161	.69	74284	2.90		
7430	.18	7493	.35	74162	.69	74285	2.90		
7432	.29	7494	.65	74163	.69	74290	1.49		
7437	.25	7495	.50	74164	.69	74298	1.49		
7438	.29	7496	.69	74165	.69	74365	.55		
7439	.58	7497	2.70	74166	.85	74366	.55		
7440	.19	74100	1.50	74167	2.75	74367	.55		
7441	.79	74107	.24	74170	1.25	74368	.55		
7442	.45	74109	.37	74172	4.75	74390	1.45		
7443	1.15	74116	1.45	74173	.69	74393	1.33		
7444	1.15	74121	.29	74174	.69	74490	2.25		
7445	.68	74122	.44	74175	.69				

74LS00

74LS00	$ .22	74LS113	$ .38	74LS247	$ .74				
74LS01	.22	74LS114	.39	74LS248	.98				
74LS02	.22	74LS122	.45	74LS249	.98				
74LS03	.22	74LS123	.95	74LS251	.59				
74LS04	.24	74LS124	2.75	74LS253	.59				
74LS05	.25	74LS125	.49	74LS257	.59				
74LS08	.27	74LS126	.49	74LS258	.59				
74LS09	.28	74LS132	.59	74LS259	2.95				
74LS10	.25	74LS136	.39	74LS260	.59				
74LS11	.33	74LS138	.59	74LS261	2.49				
74LS12	.33	74LS139	.59	74LS266	.55				
74LS13	.39	74LS145	1.19	74LS273	1.45				
74LS14	.59	74LS146	1.38	74LS275	3.29				
74LS15	.33	74LS151	.55	74LS279	.59				
74LS20	.25	74LS153	.55	74LS283	.68				
74LS21	.29	74LS154	1.49	74LS290	.88				
74LS22	.29	74LS155	.69	74LS293	.98				
74LS26	.29	74LS156	.69	74LS295	.98				
74LS27	.29	74LS157	.65	74LS298	.88				
74LS28	.29	74LS158	.59	74LS324	1.75				
74LS30	.25	74LS160	.69	74LS347	1.95				
74LS32	.33	74LS161	.69	74LS348	1.95				
74LS33	.53	74LS162	.69	74LS352	1.25				
74LS37	.35	74LS163	.69	74LS353	1.25				
74LS38	.35	74LS164	.69	74LS363	1.29				
74LS40	.25	74LS165	.90	74LS365	.48				
74LS42	.44	74LS166	1.90	74LS366	.48				
74LS47	.74	74LS168	1.15	74LS367	.45				
74LS48	.74	74LS169	1.15	74LS368	.45				
74LS51	.25	74LS170	1.40	74LS373	1.39				
74LS54	.29	74LS173	.69	74LS374	1.39				
74LS55	.29	74LS174	.67	74LS375	.69				
74LS73	.35	74LS175	.67	74LS377	1.38				
74LS74	.34	74LS181	1.95	74LS385	1.95				
74LS75	.39	74LS190	.85	74LS386	.45				
74LS76	.39	74LS191	.85	74LS390	1.15				
74LS78	.39	74LS192	.78	74LS393	1.15				
74LS83	.59	74LS193	.78	74LS395	1.15				
74LS85	.69	74LS194	.69	74LS399	1.47				
74LS86	.39	74LS195	.69	74LS424	2.95				
74LS90	.54	74LS196	.79	74LS668	1.75				
74LS92	.54	74LS197	.79	74LS670	2.29				
74LS93	.54	74LS221	.89	81LS95	1.45				
74LS95	.75	74LS240	.95	81LS96	1.45				
74LS96	.89	74LS242	.95	81LS97	1.45				
74LS107	.39	74LS243	.95	81LS98	1.45				
74LS109	.39	74LS244	1.25	25LS2521	2.65				
74LS112	.39	74LS245	1.45	25LS2569	3.50				

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74S04	.45	74S112	.55	74S174	1.19	74S288*	1.95
74S05	.45	74S113	.55	74S175	1.19	74S373	2.09
74S08	.39	74S114	.55	74S188*	1.49	74S374	2.09
74S09	.39	74S124	2.69	74S194	1.49	74S387*	1.95
74S10	.35	74S132	1.39	74S195	1.49	74S471*	5.95
74S11	.35	74S133	.45	74S196	1.49	74S472*	4.95
74S15	.35	74S134	.50	74S240	1.99	74S473*	4.95
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SN7407N	14	.59
SN7408N	14	.29
SN7409N	14	.35
SN7410N	14	.29
SN7411N	14	.29
SN7412N	14	.49
SN7413N	14	.39
SN7414N	14	.49
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SN7421N	14	.59
SN7422N	14	.59
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SN7425N	14	.39
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SN7437N	14	.25
SN7438N	14	.49
SN7439N	14	.79
SN7440N	14	.19
SN7441N	16	.89
SN7442N	16	.45
SN7443N	16	1.25
SN7444N	16	1.25
SN7445N	16	.69
SN7446N	16	.75
SN7447N	16	.75
SN7448N	16	.75
SN7454N	14	.19
SN7459N	14	.35
SN7460N	14	.39
SN7470N	14	.39
SN7472N	14	.39
SN7473N	14	.39

Part No.	Pins	Price
SN7474N	14	.39
SN7475N	16	.45
SN7476N	16	.39
SN7479N	14	4.95
SN7480N	14	.89
SN7482N	14	1.49
SN7483N	16	.55
SN7485N	16	.59
SN7486N	14	.39
SN7489N	16	2.25
SN7490N	14	.49
SN7491N	14	.79
SN7492N	14	.45
SN7493N	14	.45
SN7494N	16	.69
SN7495N	14	.49
SN7496N	16	.49
SN7497N	16	3.25
SN74100N	24	1.95
SN74105N	14	1.19
SN74107N	14	.29
SN74109N	16	.39
SN74116N	24	1.49
SN74121N	14	.45
SN74122N	14	.69
SN74123N	16	.55
SN74125N	14	.49
SN74126N	14	.49
SN74128N	14	.79
SN74132N	14	.59
SN74136N	14	.59
SN74141N	16	.89
SN74142N	16	3.95
SN74143N	24	3.95
SN74144N	24	3.95
SN74145N	16	.65
SN74147N	16	1.29
SN74148N	16	.89
SN74150N	24	1.49
SN74151N	16	.49
SN74152N	14	.49
SN74153N	16	.99
SN74154N	24	1.49
SN74155N	16	.49
SN74156N	16	.59
SN74157N	16	.49

Part No.	Pins	Price
SN74159N	24	1.95
SN74160N	16	.59
SN74161N	16	.59
SN74162N	16	.59
SN74163N	16	.59
SN74164N	14	.69
SN74165N	16	.69
SN74166N	16	.69
SN74167N	16	2.95
SN74170N	16	1.59
SN74172N	24	4.95
SN74173N	16	.85
SN74174N	16	.69
SN74175N	16	.59
SN74176N	14	.79
SN74177N	14	.79
SN74179N	16	1.49
SN74180N	14	.69
SN74181N	24	1.95
SN74182N	16	1.05
SN74184N	16	2.29
SN74185N	16	2.29
SN74190N	16	.69
SN74191N	16	.69
SN74192N	16	.69
SN74193N	16	.69
SN74194N	16	.69
SN74195N	16	.49
SN74196N	14	.75
SN74197N	14	.75
SN74198N	24	1.19
SN74199N	24	1.19
SN74221N	16	1.19
SN74251N	16	.79
SN74273N	20	1.95
SN74276N	20	2.49
SN74279N	16	.79
SN74283N	16	1.39
SN74284N	16	2.95
SN74285N	16	2.95
SN74365N	16	.55
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74LS

Part No.	Pins	Price
74LS00	14	.29
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74LS02	14	.35
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74LS04	14	.39
74LS05	14	.35
74LS06	14	.99
74LS07	14	.99
74LS08	14	.35
74LS09	14	.35
74LS10	14	.35
74LS11	14	.35
74LS14	14	.59
74LS20	14	.29
74LS21	14	.35
74LS26	14	.29
74LS27	14	.35
74LS28	14	.39
74LS30	14	.39
74LS32	14	.39
74LS37	14	.35
74LS38	14	.39
74LS42	16	.49
74LS47	16	.89
74LS51	14	.29
74LS73	14	.39
74LS74	14	.49
74LS75	16	.45
74LS76	16	.39
74LS85	16	.89
74LS86	14	.39
74LS90	14	.55
74LS92	14	.55
74LS93	14	.59
74LS96	16	.89
74LS107	14	.39
74LS109	16	.39
74LS112	16	.45
74LS122	14	.49
74LS123	16	.79
74LS125	14	.59
74LS126	14	.59

Part No.	Pins	Price
74LS132	14	.65
74LS133	16	.59
74LS136	14	.39
74LS138	16	.59
74LS139	16	.59
74LS145	16	1.19
74LS147	16	1.95
74LS148	16	1.79
74LS151	16	.59
74LS153	16	.59
74LS154	24	1.49
74LS155	16	.69
74LS156	16	.69
74LS157	16	.69
74LS158	16	.59
74LS160	16	.69
74LS161	16	.69
74LS162	16	.69
74LS163	16	.69
74LS164	14	.89
74LS165	16	.89
74LS168	16	1.19
74LS169	16	1.49
74LS170	16	1.49
74LS173	16	.69
74LS174	16	.69
74LS175	16	.69
74LS181	24	2.49
74LS190	16	.79
74LS191	16	.89
74LS192	16	.79
74LS193	16	.89
74LS194	16	.69
74LS195	16	.59
74LS196	14	.89
74LS197	14	.89
74LS221	16	1.09
74LS240	20	1.09
74LS241	20	.99
74LS243	14	1.09

Part No.	Pins	Price
74LS244	20	1.29
74LS245	20	1.49
74LS251	16	.59
74LS253	16	.59
74LS257	16	.59
74LS258	16	.59
74LS260	14	.59
74LS266	14	.49
74LS273	20	1.49
74LS279	16	.49
74LS280	14	1.95
74LS299	20	2.95
74LS322	20	3.95
74LS323	20	3.95
74LS347	16	.79
74LS353	16	1.09
74LS364	20	1.95
74LS365	16	.49
74LS366	16	.49
74LS367	16	.49
74LS368	16	.49
74LS373	20	1.49
74LS374	20	1.49
74LS375	16	.69
74LS386	14	.39
74LS393	14	1.19
74LS399	16	1.49
74LS490	16	1.95
74LS533	20	1.95
74LS534	20	1.95
74LS540	20	1.49
74LS541	20	1.49
74LS640	20	2.19
74LS641	20	2.19
74LS644	20	2.19
74LS645	20	2.19
74LS670	16	1.49
74LS688	20	2.95
81LS95	20	1.49
81LS96	20	1.49
81LS97	20	1.49
81LS98	20	1.49

74S/PROMS*

Part No.	Pins	Price
74S00	14	.35
74S02	14	.35
74S04	14	.45
74S05	14	.45
74S08	14	.45
74S09	14	.39
74S10	14	.35
74S11	14	.35
74S15	14	.35
74S20	14	.35
74S22	14	.35
74S30	14	.35
74S32	14	.45
74S37	14	.99
74S38	14	.89
74S64	14	.39
74S65	14	.39
74S74	14	.55
74S85	16	1.99
74S86	14	.55
74S112	16	.55
74S124	16	2.75

Part No.	Pins	Price
74S132	14	1.89
74S133	16	.45
74S135	16	.89
74S136	14	1.39
74S138	16	.89
74S139	16	.89
74S140	14	.69
74S151	16	.99
74S153	16	.99
74S157	16	.99
74S158	16	.99
74S160	16	2.29
74S169	16	4.29
74S174	16	1.09
74S175	16	1.09
74S188*	16	1.75
74S194	16	1.49
74S195	16	1.49
74S196	14	1.49
74S240	20	1.95

Part No.	Pins	Price
74S241	20	1.95
74S242	14	2.19
74S244	20	2.19
74S251	16	.99
74S253	16	.99
74S257	16	.99
74S258	16	.99
74S273	20	2.39
74S280	14	1.89
74S287*	16	1.79
74S288*	16	1.79
74S299	20	5.95
74S373	20	2.49
74S374	20	2.49
74S387*	16	1.95
74S471*	20	4.95
74S472*	20	4.95
74S473*	20	4.95
74S570*	16	2.95
74S571*	16	2.95
74S572*	18	4.95
74S573*	18	4.95

74ALS

Part No.	Pins	Price
74ALS00	14	.59
74ALS02	14	.59
74ALS04	14	.59
74ALS08	14	.59
74ALS10	14	.59
74ALS30	14	.59
74ALS32	14	.65
74ALS74	14	.79
74ALS109	16	.79
74ALS112	16	.69
74ALS138	16	1.25
74ALS240	20	2.25
74ALS244	20	2.25
74ALS245	20	2.59
74ALS373	20	2.59
74ALS374	20	2.59

74F

Part No.	Pins	Price
74F00	14	.69
74F02	14	.75
74F04	14	.89
74F08	14	.75
74F10	14	.75
74F20	14	.69
74F32	14	.79
74F74	14	.85
74F86	14	1.15
74F109	16	.95
74F138	16	1.69
74F139	16	1.49
74F157	16	1.69
74F158	16	1.69
74F240	20	3.75
74F244	20	3.49
74F253	16	1.79
74F257	16	1.79
74F280	14	1.69
74F373	20	4.89
74F374	20	4.59
74F379	16	1.99

CD—CMOS

Part No.	Pins	Price
CD4000	14	.29
CD4001	14	.29
CD4002	14	.29
CD4006	14	.89
CD4007	14	.29
CD4008	16	.89
CD4009	16	.59
CD4010	16	.49
CD4011	14	.29
CD4012	14	.29
CD4013	14	.39
CD4014	16	.89
CD4015	16	.39
CD4016	14	.49
CD4017	16	.79
CD4018	16	.79
CD4019	16	.49
CD4020	16	.75
CD4021	16	.75
CD4022	16	.75
CD4023	14	.29
CD4024	14	.69
CD4025	14	.29
CD4026	16	1.59
CD4027	16	.45
CD4028	16	.69
CD4029	16	.79
CD4030	14	.39
CD4034	24	1.79
CD4035	16	.79
CD4040	16	.75

Part No.	Pins	Price
CD4041	14	.69
CD4042	16	.69
CD4043	16	.79
CD4044	16	.79
CD4046	16	.89
CD4047	14	.89
CD4048	16	.59
CD4049	16	.39
CD4050	16	.39
CD4051	16	.79
CD4052	16	.89
CD4053	16	.79
CD4056	16	2.95
CD4059	24	3.95
CD4060	16	.89
CD4066	14	.45
CD4068	14	.39
CD4069	14	.35
CD4070	14	.29
CD4071	14	.29
CD4072	14	.29
CD4073	14	.29
CD4075	14	.29
CD4076	16	.89
CD4077	14	.35
CD4078	14	.49
CD4081	14	.29
CD4093	14	.49
CD4094	16	1.95
CD4098	16	1.95
CD4099	16	1.89

Part No.	Pins	Price
CD40103	16	2.49
CD4503	16	.69
CD4506	16	1.29
CD4507	14	1.19
CD4508	24	1.95
CD4510	16	.85
CD4511	16	.85
CD4512	16	.85
CD4514	24	1.49
CD4515	24	1.49
CD4516	16	.89
CD4518	16	.89
CD4519	16	.59
CD4520	16	.89
CD4522	16	1.69
CD4526	16	1.19
CD4528	16	1.19
CD4529	16	1.69
CD4531	16	.89
CD4538	16	1.49
CD4541	14	1.49
CD4543	16	1.19
CD4553	16	4.95
CD4566	16	2.95
CD4583	16	2.49
CD4584	14	.59
CD4585	16	1.39
CD4723	16	1.19
CD4724	16	1.19
MC14410	16	8.95
MC14411	24	11.95
MC14412	16	7.95
MC14433	24	17.95
MC14490P	16	4.95
MC14572	16	1.19

RED-HOT RAM & EPROM PRICES

Part No.	Description	Price
21C14	(200ns) CMOS SRAM CMOS USES LESS POWER	.99
27C16	(450ns) CMOS EPROM	9.95
4164N-200	(DRAM)	9/9.95
6116P-4	(200ns) SRAM	3.49
6116LP-4	(200ns) L.P. SRAM	3.69
6264LP-15	(150ns) L.P. SRAM	7.49
MC146818	REAL TIME CLOCK & RAM	7.95
27128-25	(250ns) EPROM	5.95
41256-150	(150ns) DRAM	6.49
68764	(450ns) 21V EPROM	12.95
68766	(350ns) 25V EPROM	14.95

MICROPROCESSOR COMPONENTS

MICROPROCESSOR CHIPS

Part No.	Pins	Function	Price
D765AC	40	Floppy Disk Controller	16.95
D3242	28	Addr. Multiplexer & Refresh Counter	7.95
TMS5501	40	Synchronous Data Interface (SIRC)	14.95
Z80, Z80A, Z80B, Z8000 SERIES			
Z80	40	CPU (MK3880N)(780C) 2.5MHz	2.75
Z80-CTC	28	Counter Timer Circuit	3.49
Z80-DART	40	Dual Asynchronous Rec./Trans.	8.95
Z80-DMA	40	Direct Memory Access Circuit	12.49
Z80-P10	40	Parallel I/O Interface Controller	2.95
Z80-S10/0	40	Serial I/O (TxCB and RxCB Bonded)	11.49
Z80-S10/1	40	Serial I/O (Lacks DTRB)	11.49
Z80-S10/2	40	Serial I/O (Lacks SYNCB)	11.49
Z80-S10/9	40	Serial I/O	11.49
Z80A	40	CPU (MK3880N-4)(780C-1) 4MHz	2.95
Z80A-CTC	28	Counter Timer Circuit	3.95
Z80A-DART	40	Dual Asynchronous Rec./Trans.	9.95
Z80A-DMA	40	Direct Memory Access Circuit	12.95
Z80A-P10	40	Parallel I/O Interface Controller	3.95
Z80A-S10/0	40	Serial I/O (TxCB and RxCB Bonded)	11.95
Z80A-S10/1	40	Serial I/O (Lacks DTRB)	11.95
Z80A-S10/2	40	Serial I/O (Lacks SYNCB)	11.95
Z80A-S10/9	40	Serial I/O	11.95
Z80B	40	CPU (MK3880N-6) 6MHz	8.95
Z80B-CTC	28	Counter Timer Circuit	11.95
Z80B-DART	40	Dual Asynchronous Rec./Trans.	19.95
Z80B-P10	40	Parallel I/O Interface Controller	10.95
6500/6800/68000 SERIES			
6502	40	MPU with Clock (1MHz)	4.95
6502A	40	MPU with Clock (2MHz)	5.25
6502B	40	MPU with Clock (3MHz)	7.95
6520	40	Peripheral Inter. Adapter	2.75
6522	40	Versatile Inter. Adapter	4.95
6551	28	Async. Comm. Interface Adapt.	6.95
6800	40	MPU	2.95
6802	40	MPU with Clock and RAM	3.95
6809	40	CPU – 8-Bit (On-Chip Oscillator)	9.95
6809E	40	CPU – 8-Bit (External Clocking)	8.49
68B09E	40	CPU – 8-Bit (Ext. Clocking) 2MHz	11.49
6810	24	128x8 Static RAM	2.75
68B10	24	128x8 Static RAM (2MHz)	5.95
6821	40	Peripheral Inter. Adapt. (MC6820)	2.75
68B21	40	Peripheral Interface Adapter (2MHz)	4.95
6845	40	CRT Controller (CRTC)	9.95
68B45	40	CRT Controller (CRTC) 2MHz	14.95
6850	24	Asynchronous Comm. Adapter	2.95
6860	24	0-600bps Digital MODEM	6.95
68000L8	64	MPU 16-Bit (8MHz)	19.95
68488P	40	General Purpose Int. Adapter	9.95
68661	28	Enhanced Prog. Comm. Interface (2661)	8.95
8000/80000 SERIES			
8031	40	Control Oriented CPU w/RAM & I/O	12.95
8035	40	MPU – 8-Bit	4.95
8039	40	CPU – Sgl. Chip 8-Bit (128 bts. RAM)	4.95
8080	40	CPU – 8-Bit NMOS	12.95
8073N	40	CPU w/Basic Micro Interpreter	29.95
8080A	40	CPU	3.95
8085A	40	CPU	3.95
8085A-2	40	CPU 8-Bit N-Channel (5MHz)	10.95
8086-2	40	CPU 16-bit 8MHz	19.95
8087	40	Arithmetic Processor (5MHz)	119.00
8087-2	40	Arithmetic Processor (8MHz)	125.00
8088	40	CPU 8/16-Bit	14.95
8116	18	Dual Baud Rate Generator	9.49
8155	40	HMOS RAM I/O Port-Timer	4.95
8156	40	RAM with I/O Port and Timer	3.95
8202	40	Dynamic RAM Controller	19.95
8203	40	64K Dynamic RAM Controller	29.95
8205	16	Hi Speed 1 out of 8 Binary Decoder	3.95
8212	24	8-Bit Input/Output (74S412)	2.25
8224	16	Clock Generator/Driver	2.19
8228	28	Sys. Cont./Bus Driver (74S428)	3.95
8237-5	40	High Perf. Prog. DMA Cont. (5MHz)	12.95
8238	28	System Controller (74S438)	4.95
8243	24	I/O Expander for 48 Series	3.95
8250A	40	Async. Comm. Element	9.95
8250B	40	ACE (IBM PC or XT Software Compatible)	11.95
8251	28	Prog. Comm. I/O (USART)	3.25
8251A	28	Prog. Comm. Interface (USART)	3.49
8253-5	24	Prog. Interval Timer	6.49
8254	24	Programmable Interval Timer	13.49
8255	40	Prog. Peripheral I/O (PPI)	3.95
8255A-5	40	Prog. Peripheral I/O (PPI) 5MHz	4.25
8257-5	40	Prog. DMA Controller	6.95
8259	28	Prog. Interrupt Control	5.95
8259-5	28	Prog. Interrupt Controller	6.95
8272	40	Sgle/Dble Density Floppy Disk Cont.	16.95
8274	40	Multi-Protocol Serial Cont. (7201)	14.95
8275	40	Prog. CRT Controller	14.95
8279	40	Prog. Keyboard/Display Interface	5.49
8279-5	40	Prog. Keyboard/Display Interface	5.95
8282	20	Octal Latch	6.49
8284	18	Clock Generator/Driver	5.49
8286	20	Octal Bus Transceiver	6.49
8287	20	Octal Bus Transceiver (Inverted)	6.49
8288	20	Bus Controller	13.95
8289	20	Bus Arbiter	24.95
8741	40	8-Bit Univ. Peripheral Interface	19.95
8748	40	HMOS EPROM MPU	19.95
8749	40	MPU 8-Bit (EPROM Version of 8049)	19.95
8751	40	CPU w/4Kx8 EPROM & 128x8 RAM	29.95
8755	40	16K EPROM with I/O	19.95
80186	68	High Integration 16-Bit MPU	19.95
80188	68	High Integra. 16-Bit MPU (8-Bit Data Bus)	19.95
80287	40	Numeric Processor Ext.	195.00
SPECIAL FUNCTION			
MC3470P	18	Floppy Disk Read Amp System	4.95
MM5321N	18	TV Camera Sync. Generator	9.95
MM58167AN	24	Microprocessor Real Time Clock	8.95
MM58174AN	16	Micro. Compatible Time Clock	8.95
MM5369AA/N	8	Prog. Oscillator/Divider (60Hz)	1.79
MM5369EST	8	Prog. Oscillator/Divider (100Hz)	1.95
MC146818	24	Real Time Clock Plus RAM	7.95

DYNAMIC RAMS

Part No.	Pins	Function	Price
4103	18	1024x1 (300ns)	.99
4027	16	4096x1 (250ns)	1.49
4116N-15	16	16384x1 (150ns)	1.39 – 8/10.95
4116N-20	16	16384x1 (200ns)	.79 – 8/6.29
4116N-25	16	16384x1 (250ns)	.69 – 8/5.49
4164N-150	16	65536x1 (150ns)	10.95
4164N-200	16	65536x1 (200ns)	1.11 – 9/9.95
MM5261	16	1024x1 (300ns)	.35 – 8/1.95
MM5262	22	2048x1 (365ns)	1.95
MM5270	18	4096x1 (250ns)	4.95
MM5280	22	4096x1 (200ns) 2107	3.95
MM5298-3	16	8192x1 (200ns)	.59
8118	16	16384x1 (120ns) (+5V Only Req.)	.99
41256-150	16	262,144x1 (150ns)	6.49
41256-200	16	262,144x1 (200ns)	5.95
4128	16	131,072x1 (250ns)	8.95

STATIC RAMS

Part No.	Pins	Function	Price
2101	22	256x4 (450ns) 8101	1.95
2102	16	1024x1 (350ns)	.89
2102-2L	16	1024x1 (250ns) L.P. (91L02)	1.49
2111	18	256x4 (450ns) 8111	2.49
2112	16	256x4 (450ns) MOS	2.49
2114N	18	1024x4 (450ns)	1.29 – 8/9.95
2114N-L	18	1024x4 (450ns) L.P.	1.65 – 8/12.95
2114N-2	18	1024x4 (200ns)	1.39 – 8/10.95
2114N-2L	18	1024x4 (200ns) L.P.	1.69 – 8/13.49
2147HN	18	4096x1 (70ns)	4.49
2148HN	18	1024x4 (70ns)	4.95
TMS4045	18	1024x4 (450ns)	3.95
TMS40L47-45	20	1024x4 (450ns)	1.95
5101	22	256x4 (450ns) CMOS	2.95
MM5257	18	4096x1 (450ns) 4044	4.95
HM6116P-2	24	2048x8 (120ns) CMOS	4.95
HM6116LP-2	24	2048x8 (120ns) L.P. CMOS	6.49
HM6116P-3	24	2048x8 (150ns) CMOS	3.75
HM6116LP-3	24	2048x8 (150ns) L.P. CMOS	3.95
HM6116P-4	24	2048x8 (200ns) CMOS	3.49
HM6116LP-4	24	2048x8 (200ns) L.P. CMOS	3.69
HM6264P-12	28	8192x8 (120ns) CMOS	7.25
HM6264LP-12	28	8192x8 (120ns) L.P. CMOS	7.95
HM6264P-15	28	8192x8 (150ns) CMOS	6.95
HM6264LP-15	28	8192x8 (150ns) L.P. CMOS	7.49
27LS00	16	256x1 (80ns) L.P.	3.95
7489	16	16x4 (50ns) 3101	2.25
74C921	18	256x4 (250ns) CMOS	5.95
74C930	18	1024x1 (250ns) CMOS (6518)	5.95
74S189	16	16x4 (35ns) 93405	2.95
74S289	16	16x4 (35ns) 3101	2.95
82S10	16	1024x1 (50ns) O.C. (93415)	3.95
82S25	16	16x4 (50ns) O.C. (74S289)	2.25

PROMS/EPROMS

Part No.	Pins	Function	Price
1702A	24	256x8 (1µs)	3.95
TMS2516	24	2048x8 (450ns)	4.95
TMS2532	24	4096x8 (450ns)	5.49
TMS2564	28	8192x8 (450ns)	10.95
2708	24	1024x8 (450ns)	3.95
TMS2716	24	2048x8 (450ns) 3 voltage	7.95
2716	24	2048x8 (450ns)	3.95
2716-1	24	2048x8 (350ns)	9.95
2716Q-5	24	2048x8 (550ns)	4.95
2732	24	4096x8 (450ns)	3.75
2732A	24	4096x8 (250ns) 21V	4.25
2732A-20	24	4096x8 (200ns) 21V	9.95
2732A-25	24	4096x8 (250ns) 21V	5.95
2732A-45	24	4096x8 (450ns) 21V	4.49
27C32	24	4096x8 CMOS	11.95
27C32A-30	24	4096x8 (300ns) 21V (CMOS)	22.95
2764	28	8192x8 (450ns) 21V	6.95
2764-20	28	8192x8 (200ns) 21V	5.09
2764-25	28	8192x8 (250ns) 21V	5.95
2764-45	28	8192x8 (450ns) 12.5V	4.95
27C64	28	8192x8 (250ns) CMOS 21V	11.95
27128-25	28	16,384x8 (250ns) 128K 21V	5.95
27128A-25	28	16,384x8 (250ns) 128K 12.5V	7.95
27256-25	28	32,768x8 (250ns) 256K (14V)	11.95
68764	24	8192x8 (450ns) 21V	12.95
68766	24	8192x8 (350ns) 25V	14.95
74S188	16	32x8 PROM O.C. (6330-1)	1.75
74S287	16	256x4 PROM T.S. (6301-1)	1.79
74S288	16	32x8 PROM T.S. (6331-1)	1.79
74S387	16	256x4 PROM O.C. (6300-1)	1.95
74S471	20	256x8 PROM T.S. (6309-1)	4.95
74S472	20	512x8 PROM T.S. (6349-1)	4.95
74S473	20	512x8 PROM O.C. (6348)	4.95
74S474	24	512x8 PROM T.S. (DM87S296N)	4.95
74S475	24	512x8 PROM O.C. (6340)	4.95
74S476	18	1024x4 PROM T.S.	6.95
74S478	24	1024x8 PROM T.S.	9.95
74S570	16	512x4 PROM O.C. (6305)	2.95
74S571	16	512x4 PROM T.S. (6306)	2.95
74S572	18	1024x4 PROM O.C. (6352)	4.95
74S573	18	1024x4 PROM T.S. (82S137)	4.95
82S23	16	32x8 PROM O.C. (27S18)	2.95
82S115	24	512x8 PROM T.S. (27S15)	9.95
82S123	16	32x8 PROM T.S. (27S19)	2.95
82S126	16	256x4 PROM O.C. (27S20)	2.95
82S129	16	256x4 PROM T.S. (27S21)	2.95
82S130	16	512x4 PROM O.C. (27S12)	3.95
82S185	18	2048x4 PROM T.S. (TBP24S81)	9.95
82S191	24	2048x8 (80ns)	14.95
DM87S181N	24	1024x8 PROM T.S. (82S181)	9.95

DATA ACQUISITION

Part No.	Pins	Function	Price
DC10		Mostek DC/DC Converter +5V to –9V	2.95
ADC0801	20	8-Bit A/D Converter (1/4LSB)	14.95
ADC0803	20	8-Bit A/D Converter (1/2LSB)	4.95
ADC0804	20	8-Bit A/D Converter (1LSB)	3.49
ADC0808	28	8-Bit A/D Conv. w/8-Channel Analog	9.95
ADC0809	28	8-Bit A/D Converter (8-Ch. Multi.)	4.49
ADC0816	40	8-Bit A/D Conv. w/16-Ch. Analog	14.95
ADC0817	40	8-Bit A/D Converter (16-Ch. Multi.)	9.49
DAC0806	16	8-Bit D/A Converter (0.78% Lin.)	1.95
DAC0807	16	8-Bit D/A Converter (MC1406-7)	1.49
DAC0808	16	8-Bit D/A Converter (MC1408-8)	2.25
DAC0830	20	8-Bit Up D/A Conv. (.05% Lin.)	5.95
DAC0831	20	8-Bit Up D/A Conv. (.10% Lin.)	4.49
DAC1000	24	10-Bit D/A Conv. Micro. Comp. (0.05%)	7.95
DAC1008	20	10-Bit D/A Conv. Micro. Comp. (0.20%)	6.95
DAC1020	16	10-Bit D/A Conv. (0.05% Lin.)	5.95
DAC1022	16	10-Bit D/A Conv. (0.20% Lin.)	5.95
DAC1222	18	12-Bit D/A Conv. (0.20% Lin.)	6.95
DAC1230	20	12-Bit Up D/A Conv. (.05% Lin.)	14.95
DAC1231	20	12-Bit Up D/A Conv. (.10% Lin.)	13.95
AY-3-1015D	40	UART	4.25
AY-5-1013A	40	30K Baud UART (TR1602)	3.95

Low Profile (Tin) Sockets

Part No.	1-9	10-99	100-up
8 pin LP	.16	.14	.13
14 pin LP	.17	.15	.14
16 pin LP	.19	.17	.16
18 pin LP	.26	.24	.23
20 pin LP	.30	.27	.25
22 pin LP	.31	.28	.26
24 pin LP	.33	.30	.28
28 pin LP	.40	.37	.35
40 pin LP	.49	.46	.43

Soldertail (Gold) Standard

Part No.	1-9	10-99	100-up
8 pin SG	.39	.35	.29
14 pin SG	.49	.45	.39
16 pin SG	.55	.49	.45
18 pin SG	.65	.59	.51
20 pin SG	.75	.65	.59
22 pin SG	.75	.69	.59
24 pin SG	.79	.69	.65
28 pin SG	.95	.85	.75
36 pin SG	1.25	1.15	.99
40 pin SG	1.39	1.25	1.15

Wire Wrap Sockets (Gold) Level #3

Part No.	1-9	10-99	100-up
8 pin WW	.55	.49	.45
10 pin WW	.69	.59	.55
14 pin WW	.75	.69	.65
16 pin WW	.79	.72	.65
18 pin WW	.95	.85	.75
20 pin WW	1.19	1.09	.95
22 pin WW	1.29	1.19	1.05
24 pin WW	1.35	1.19	1.09
28 pin WW	1.69	1.55	1.39
36 pin WW	1.99	1.79	1.69
40 pin WW	1.99	1.85	1.79

Header Plugs (Gold)

Part No.	1-9	10-99	100-up
14 pin HP	.65	.59	.55
16 pin HP	.69	.65	.59
24 pin HP	1.15	.99	.89

Header Covers

Part No.	1-9	10-99	100-up
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16 pin HC	.19	.17	.15
24 pin HC	.29	.25	.22

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Part No.	Pins	Function	Price
FE0202D	40	4 Digit LCD Display for 7211IPL & 7211MIPL	14.95
FE0203D	40	3½ Digit LCD Display for 7106 & 7116	14.95
7045IPI	28	CMOS Precision Timer	14.95
7045EV/Kit	28	Stopwatch Chip, XTL (Evaluation Kit)	19.95
7106CPL	40	3½ Digit A/D (LCD Drive)	10.49
7106EV/Kit	40	IC, Circuit Board, Display (Evaluation Kit)	46.95
7107CPL	40	3½ Digit A/D (LED Drive)	10.95
7107EV/Kit	40	IC, Circuit Board, Display (Evaluation Kit)	46.95
7116CPL	40	3½ Digit A/D LCD Dis. HLD	10.95
7201IUS		Low Battery Volt. Indicator	2.25
7205IPG	24	CMOS LED Stopwatch/Timer	14.95
7205EV/Kit	24	Stopwatch Chip, XTL (Evaluation Kit)	16.95
7206CJPE	16	Tone Generator	4.95
7206CEV/Kit	16	Tone Generator Chip, XTL (Evaluation Kit)	7.95
7207AIPD	14	Oscillator Controller	5.95
7207AEV/Kit	14	Freq. Counter Chip, XTL (Evaluation Kit)	8.49
7211IPL	40	4 Digit LCD Display Decoder/Driver (TTL compatible)	7.95
7211MIPL	40	4 Digit LCD Display Decoder/Driver (Microproc. compat.)	8.95
7215IPG	24	4 Func. CMOS Stopwatch CKT	16.95
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7216AIJI	28	8 Digit Univ. Counter C.A.	31.49
7216DIPI	28	8 Digit Freq. Counter C.C.	21.49
7217IJI	28	4 Digit LED Up/Down Counter C.A.	10.95
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74HC HIGH SPEED CMOS

Part No.	Pins	Price
74HC00	14	.59
74HC02	14	.59
74HC03	14	.89
74HC04	14	.59
74HCU04	14	.69
74HC08	14	.59
74HC10	14	.59
74HC11	14	.69
74HC14	14	.89
74HC20	14	.59
74HC27	14	.59
74HC30	14	.69
74HC32	14	.79
74HC42	16	1.09
74HC51	14	.89
74HC58	14	.89
74HC73	14	.79
74HC74	14	.79
74HC75	16	.99
74HC76	16	.79
74HC85	16	1.69
74HC86	14	.75
74HC107	14	.79
74HC109	16	.79
74HC112	16	.79
74HC123	16	2.29
74HC125	14	1.75
74HC132	14	1.29
74HC137	16	1.59
74HC138	16	1.19

Part No.	Pins	Price
74HC139	16	1.05
74HC147	16	1.29
74HC151	16	.99
74HC153	16	1.09
74HC154	24	2.65
74HC157	16	.99
74HC158	16	.99
74HC160	16	1.39
74HC161	16	1.39
74HC162	16	1.39
74HC163	16	1.39
74HC164	14	1.35
74HC165	16	2.15
74HC166	16	2.49
74HC173	16	1.29
74HC174	16	1.09
74HC175	16	1.09
74HC190	16	1.59
74HC191	16	1.59
74HC192	16	1.49
74HC193	16	1.49
74HC194	16	1.19
74HC195	16	1.19
74HC221	16	2.95
74HC237	16	1.49
74HC240	20	2.29
74HC241	20	2.29
74HC242	14	2.15
74HC243	14	2.15
74HC244	20	2.29

Part No.	Pins	Price
74HC245	20	2.59
74HC251	16	.99
74HC253	16	1.09
74HC257	16	.99
74HC259	16	1.69
74HC266	14	.89
74HC273	20	2.79
74HC280	14	4.59
74HC299	20	5.59
74HC366	16	2.59
74HC367	16	2.59
74HC373	20	2.69
74HC374	20	2.69
74HC390	16	1.59
74HC393	14	1.59
74HC533	20	2.69
74HC534	20	2.69
74HC595	16	3.19
74HC688	20	3.59
74HC4024	14	1.75
74HC4040	16	1.49
74HC4049	16	.89
74HC4050	16	.89
74HC4060	16	1.49
74HC4075	14	.59
74HC4078	14	.59
74HC4511	16	1.95
74HC4514	24	4.19
74HC4538	16	2.59
74HC4543	16	3.75

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74C—C/MOS

Part No.	Pins	Price
74C00	14	.29
74C02	14	.35
74C04	14	.35
74C08	14	.35
74C10	14	.35
74C14	14	.59
74C20	14	.35
74C30	14	.35
74C32	14	.39
74C42	16	1.19
74C48	16	1.79
74C73	14	.69
74C74	14	.59
74C85	16	1.39
74C86	14	.29
74C89	16	5.95
74C90	14	1.09
74C93	14	1.09
74C95	14	1.19

Part No.	Pins	Price
74C107	14	.79
74C151	16	2.19
74C154	24	3.25
74C157	16	1.75
74C160	16	1.19
74C161	16	1.19
74C162	16	1.19
74C163	16	1.19
74C164	14	1.29
74C165	16	1.29
74C173	16	.89
74C174	16	1.19
74C175	16	1.19
74C192	16	1.39
74C193	16	1.39
74C195	16	1.29
74C221	16	1.75

Part No.	Pins	Price
74C240	20	1.95
74C244	20	1.95
74C373	20	2.29
74C374	20	2.29
74C901	14	.59
74C902	14	.79
74C903	14	.59
74C906	14	.59
74C907	14	.89
74C911	28	8.95
74C912	28	8.95
74C915	18	1.19
74C917	28	8.95
74C922	18	4.49
74C923	20	4.95
74C925	16	5.95
74C926	18	5.95
80C95	16	.69
80C97	16	.69

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Part No.	Pins	Price
DS0026CN	8	1.95
TL071CP	8	.79
TL072CP	8	1.09
TL074CN	14	1.95
TL081CP	8	.59
TL082CP	8	1.19
TL084CN	14	1.95
LM109K		5.95
LM301CN	8	.39
LM302H		2.49
LM304H		1.95
LM305H		.99
LM307CN	8	.49
LM308CN	8	.69
LM309K		1.25
LM310CN	8	1.95
LM311CN	8	.59
LM312H		2.79
LM317T		1.19
LM317K		3.49
LM318CN	8	1.59
LM319N	14	1.49
LM320K-5		1.35
LM320K-12		1.35
LM320K-15		1.35
LM320K-24		1.35
LM320T-5		.85
LM320T-12		.85
LM320T-15		.85
LM320T-24		.85
LM322N	14	1.49
LM323K		4.95
LM324N	14	.59
LM329DZ		.65
LM331N	8	3.95
LM334Z		1.19
LM335Z		1.29
LM336Z		1.09
LM337MP		1.15
LM337T		1.89
LM338K		6.95
LM339N	14	.69
LM340K-5		1.35
LM340K-12		1.35
LM340K-15		1.35
LM340K-24		1.35
LM340T-5		.75
LM340T-12		.75
LM340T-15		.75
LM340T-24		.75
LF347N	14	1.49
LM348N	14	.89
LM350K		4.79
LF351N	8	.59
LF353N	8	.89

Part No.	Pins	Price
LF355N	8	1.09
LF356N	8	1.09
LM358N	8	.59
LM359N	14	1.79
LM370N	14	4.95
LM373N	14	4.95
LM377N	14	1.95
LM380CN	8	1.09
LM380N	14	.89
LM381N	14	1.79
LM382N	14	1.49
LM384N	14	1.95
LM386N-3	8	.89
LM387N	8	1.39
LM389N	18	1.19
LM391N-80	16	1.19
LM392N	8	.59
LM393N	8	.45
LF398N	8	3.95
LM399H		5.95
LF412CN	8	1.95
TL494CN	16	2.79
TL496CP	8	1.59
NE531V	8	1.79
NE540H (C540H)		2.95
NE544N	14	1.95
NE550A	14	1.95
NE555V	8	.35
XR-L555	8	.69
LM556N	14	.79
NE558N	16	1.59
NE564N	16	1.95
LM565N	14	.99
LM566CN	8	1.49
LM567V	8	.99
NE570N	16	2.95
NE571N	16	2.49
NE592N	14	1.19
LM703CN	8	1.49
LM710N	14	.69
LM711N	14	.79
LM723N	14	.49
LM733N	14	.89
LM739N	14	1.95
LM741CN	8	.39

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LM747N	14	.69
LM748N	8	.59
UA760HC		9.95
LM1456V	8	1.95
LM1458CN	8	.59
LM1488N	14	.69
LM1489N	14	.69
LM1496N	14	.99
LM1605CK		9.95
LM1871N	18	2.95
LM1872N	18	3.25
LM1877N-9	14	2.95
LM1889N	18	1.95
LM1896N	14	1.59
LM2002T		1.95
ULN2003A	16	1.49
XR2206	16	3.95
XR2207	14	2.49
XR2208	16	1.79
XR2211	14	2.95
LM2877P		1.95
LM2878P		2.95
LM2901N	14	.79
LM2902N	14	.89
LM2907N	14	2.49
LM2917N	8	1.95
LM3900N	14	.59
LM3905CN	8	1.19
LM3909N	8	.89
LM3914N	18	2.39
LM3915N	18	2.39
LM3916N	18	2.39
RC4136N	14	1.25
RC4151NB	8	1.95
RC4193NB	8	1.95
RC4195TK		5.95
LM4250CN	8	1.49
NE5532	8	1.69
NE5534	8	1.39
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Even the Very Best Radar Detector Can't Protect You from the Newest Radar

THE ULTIMATE IN RADAR PROTECTION

Radar Jammer: Compact under-dash unit causes speed radar guns to read out a percentage of your true speed, or whatever speed you dial in. Or, new "SCRAMBLE" mode will prevent radar from obtaining *any* reading. Activated by Whistler, Escort, or other detector. Best defense against instant on radar. Operates on both X and K bands. WARNING: This device is not legal for use against police radar, and is not FCC approved.

Transmitters: The heart of the jammer is the microwave oscillator (transmitter). In the past, these were *very* expensive, and limited to only about 100 milliwatts of power. We now have our own *Low Cost, High Power* Transmitters up to 300 milliwatts or more. Please call for prices.

Radar Detectors: We highly recommend using a *remote* detector that is mounted so that nothing is readily visable to either the police, or thieves. (A dash mount detector is an *invitation* to thieves and an *irritation* to police!) We agree with Motor Trend and Autoweek that WHISTLER SPECTRUM is the best detector available, and we know of *no other remote detector* that is even *in the same LEAGUE* as the SPECTRUM REMOTE. *Order the best for yourself now.* (Our detectors are already modified for direct connection to the jammer.)

ORDER TODAY-MONEY BACK GUARANTEE

☐ Complete Literature & Plans Pkg.	$ 14.95
☐ Set of Circuit Boards	40.00
☐ X and K-band Microwave Oscillators (Transmitters)	Call
☐ Whistler Spectrum (modified for use with Jammer)	259.00
☐ Whistler Spectrum Remote (modified)	259.00
☐ Modify your Spectrum for use w/jammer	55.00

CALL or send the following information:
- **Items Ordered** • **Name** • **Shipping Address**
- **Payment: Check, Money Order, VISA or MC (include card number, expiration date, and signature)**

SEND TO: Oregon Microwave Inc.*, 9513 S.W. Barbur Blvd. #109S Portland, OR 97219 **ORDER LINE:** (503) 626-6764
**Formerly Philips Instrument Design Co.*

CIRCLE 291 ON FREE INFORMATION CARD

AMAZING DEVICES

PHASORS

PERSONAL DEFENSE AND PROPERTY PROTECTION UTILIZE SPACE AGE TECHNOLOGY.
CAUTION THESE DEVICES CAN BE HAZARDOUS AND MAY SOON BE ILLEGAL.

POCKET PAIN FIELD GENERATOR — IPG50
Assembled $64.50
IPG5 .... Plans .... $8.00 **IPG5K** ..... Kit/Plans $44.50

PHASOR PAIN FIELD CROWD CONTROLLER — PPF10
Assembled $250.00
PPF1 .... Plans .... $15.00 **PPF1K** .... Kit/Plans $175.00

BLASTER - Provides a plasma discharge capable of puncturing a can. *Produces a 100,000 WATT PULSE.*
BLS10 .... ASSEMBLED $89.50
BLS1 .. PLANS .. $10.00 **BLS1K** .. KTI/PLANS .. $69.50

PLASMA STUN GUN - Very intimidating and affective 5 to 10 feet 100,000 VOLTS
ITM10 .... ASSEMBLED $99.50
ITM1 .. PLANS .. $10.00 **ITM1K** .. KIT/PLANS .. $69.50

LASERS

RUBY LASER RAY GUN — Intense visible red beam burns and welds hardest of metals. **MAY BE HAZARDOUS.**
RUB3 *All Parts Available for Completing Device* $20.00

CARBON DIOXIDE BURNING, CUTTING LASER — Produces a continuous beam of high energy. **MAY BE HAZARDOUS.**
LC5.. *All Parts Available for Completing Device* .. $20.00

VISIBLE LASER LIGHT GUN — produces intense red beam for sighting, spotting, etc. Hand held complete.
LGU3.. Plans.. $10.00 ***(Kit & Assembled Units Available)***

IR PULSED LASER RIFLE — Produces 15-30 watt infra-red pulses at 200-2000 per sec.
LRG3 .... *All Parts & Diodes Available* $10.00

BEGINNERS LOW POWER VISIBLE LASER — Choice of red, yellow, green — provides an excellent source of monochromatic light.
LHC2 .... Plans .... $5.00 **LHC2K** .... Kit $34.50

SECURITY

SNOOPER PHONE — Allows user to call his premises and listen in without phone ever ringing.
SNP20 .... Assembled $89.50
SNP2 .... Plans .... $9.00 **SNP2K** ..... Plans/Kit $59.50

LONG RANGE WIRELESS MIKE — Miniature device clearly transmits well over one mile. Super sensitive, powerful.
MFT1 .... Plans .... $7.00 **MFT1K** ..... Plans/Kit $49.50

WIRELESS TELEPHONE TRANSMITTER — Transmits both sides of phone conversation over one mile, shuts off automatically.
VWPM5 ...... Plans ...... $8.00 **VWPM5K** ... Plans/Kit ... $39.50

PWM5—LONG RANGE SUPER EAR WITH WIRELESS ATTACHMENT
PWM5 ... Plans ... $10.00 **PWM5K** .. Kit .. $139.50
PWM50 .... Assembled and Tested $169.50

Our phone is open for orders anytime. Technicians are available 9-11 a.m., Mon-Thurs for those needing assistance or information. Send $1.00 for catalog of hundreds more similar devices. Send check, cash, MO, Visa, MC, COD to: **INFORMATION UNLIMITED**
DEPT **R8**, P.O. Box 716, Amherst, N. H. 03031 Tel: 603-673-4730

CIRCLE 72 ON FREE INFORMATION CARD

SPECIAL THANKS TO ALL THE FOLKS AT RADIO ELECTRONICS

STATIC RAMS

2101	256x4	(450ns)	1.95
5101	256x4	(450ns)(CMOS)	3.95
2102-1	1024x1	(450ns)	.89
2102L-4	1024x1	(450ns)(LP)	.99
2102L-2	1024x1	(250ns)(LP)	1.45
2125	1024x1	(45ns)	1.95
2111	256x4	(450ns)	2.49
2112	256x4	(450ns)	2.99
2114	1024x4	(450ns)	.99
2114L-4	1024x4	(450ns)(LP)	1.09
2114L-2	1024x4	(200ns)(LP)	1.49
2114L-15	1024x4	(150ns)(LP)	1.95
TC5514	1024x4	(650ns)(CMOS)	4.95
2141	4096x1	(200ns)	2.95
2147	4096x1	(55ns)	3.95
2148	1024x4	(70ns)	4.95
TMS4044-4	4096x1	(450ns)	1.95
TMS4044-2	4096x1	(250ns)	2.95
UPD410	4096x1	(100ns)	3.95
MK4118	1024x8	(250ns)	9.95
TMM2016-150	2048x8	(150ns)	1.69
TMM2016-100	2048x8	(100ns)	2.49
HM6116-4	2048x8	(200ns)(CMOS)	1.79
HM6116-3	2048x8	(150ns)(CMOS)	1.89
HM6116-2	2048x8	(120ns)(CMOS)	2.95
HM6116LP-4	2048x8	(200ns)(CMOS)(LP)	1.89
HM6116LP-3	2048x8	(150ns)(CMOS)(LP)	1.99
HM6116LP-2	2048x8	(120ns)(CMOS)(LP)	2.95
TC5516	2048x8	(250ns)(CMOS)	3.95
Z-6132	4096x8	(300ns)(QSTAT)	19.95
HM6264P-15	8192x8	(150ns)(CMOS)	4.75
HM6264LP-15	8192x8	(150ns)(CMOS)(LP)	4.95
HM6264LP-12	8192x8	(120ns)(CMOS)(LP)	5.95

LP=Low power Qstat=Quasi-Static

DYNAMIC RAMS

TMS4027	4096x1	(250ns)	.95
2107	4096x1	(200ns)	1.95
MM5280	4096x1	(300ns)	1.95
TMS4050	4096x1	(300ns)	1.95
UPD411	4096x1	(300ns)	1.95
TMS4060	4096x1	(300ns)	1.95
MK4108	8192x1	(200ns)	.19
MM5298	8192x1	(250ns)	.19
4116-250	16384x1	(250ns)	.49
4116-200	16384x1	(200ns)	.69
4116-150	16384x1	(150ns)	.89
4116-120	16384x1	(120ns)	1.49
2118	16384x1	(150ns)(5v)	1.95
MK4332	32768x1	(200ns)	6.95
4164-200	65536x1	(200ns)(5v)	.79
4164-150	65536x1	(150ns)(5v)	.89
4164-120	65536x1	(120ns)(5v)	1.95
MCM6665	65536x1	(200ns)(5v)	1.95
TMS4164	65536x1	(150ns)(5v)	1.95
4164-REFRESH	65536x1	(150ns)(5V)(REFRESH)	2.95
TMS4416	16384x4	(150ns)(5v)	4.95
41128-150	131072x1	(150ns)(5v)	5.95
41256-200	262144x1	(200ns)(5v)	3.19
41256-150	262144x1	(150ns)(5v)	3.29

5v=Single 5 Volt Supply REFRESH=Pin 1 Refresh

EPROMS

1702	256x8	(1us)	4.95
2708	1024x8	(450ns)	3.95
2758	1024x8	(450ns)(5V)	4.95
2716-6	2048x8	(650ns)	2.29
2716	2048x8	(450ns)(5V)	2.49
2716-1	2048x8	(350ns)(5V)	3.95
TMS2516	2048x8	(450ns)(5V)	3.95
TMS2716	2048x8	(450ns)	6.75
TMS2532	4096x8	(450ns)(5V)	3.95
2732	4096x8	(450ns)(5V)	2.49
2732A	4096x8	(250ns)(5V)(21V PGM)	2.69
2732A-2	4096x8	(200ns)(5V)(21V PGM)	4.95
27C64	8192x8	(250ns)(5V)(CMOS)	7.95
2764	8192x8	(450ns)(5V)	2.29
2764-200	8192x8	(200ns)(5V)	4.95
TMS2564	8192x8	(450ns)(5V)	8.95
MCM68764	8192x8	(450ns)(5V)(24 pin)	16.95
MCM68766	8192x8	(350ns)(5V)(24 pin)	17.95
27128	16384x8	(250ns)(5V)	3.49
27C256	32768x8	(250ns)(5V)(CMOS)	15.95
27256	32768x8	(250ns)(5V)	9.95

5V=Single 5 Volt Supply 21V PGM=Program at 21 Volts

★★★★HIGH-TECH★★★★

NEC V20 μPD70108 $20.95

REPLACES 8088 TO SPEED UP IBM PC 10-40%

- HIGH SPEED ADDRESS CALCULATION IN HARDWARE
- PIN COMPATIBLE WITH 8088
- SUPERSET OF 8086/8088 INSTRUCTION SET
- LOW POWER CMOS

★★★★SPOTLIGHT★★★★

- COMPUTER MANAGED INVENTORY - VIRTUALLY NO BACK ORDERS!
- VERY COMPETITIVE PRICES
- FRIENDLY STAFF
- FAST SERVICE - MOST ORDERS SHIPPED WITHIN 24 HOURS!
- WE ACCEPT VISA AND MASTERCARD

CRYSTALS

32.768 KHz	.95
1.0 MHz	2.95
1.8432	2.95
2.0	1.95
2.097152	1.95
2.4576	1.95
3.2768	1.95
3.579545	1.95
4.0	1.95
4.032	1.95
5.0	1.95
5.0688	1.95
5.185	1.95
5.7143	1.95
6.0	1.95
6.144	1.95
6.5536	1.95
8.0	1.95
10.0	1.95
10.738635	1.95
12.0	1.95
14.31818	1.95
15.0	1.95
16.0	1.95
17.430	1.95
18.0	1.95
18.432	1.95
20.0	1.95
22.1184	1.95
24.0	1.95
32.0	1.95

BIT RATE GENERATORS

MC14411	9.95
BR1941	4.95
4702	9.95
COM5016	16.95
COM8116	8.95
MM5307	4.95

CRT CONTROLLERS

6845	4.95
68B45	8.95
6847	11.95
68047	12.95
HD46505SP	6.95
MC1372	2.95
8275	26.95
7220	19.95
CRT5027	12.95
CRT5037	9.95
TMS9918A	19.95
DP8350	39.95

CRYSTAL OSCILLATORS

1.0MHz	5.95	8.0	4.95
1.8432	5.95	10.0	4.95
2.0	5.95	12.0	4.95
2.4576	5.95	12.480	4.95
2.5	4.95	15.0	4.95
4.0	4.95	16.0	4.95
5.0688	4.95	18.432	4.95
6.0	4.95	20.0	4.95
6.144	4.95	24.0	4.95

74LS00

74LS00	.16	74LS191	.49
74LS01	.18	74LS192	.69
74LS02	.17	74LS193	.69
74LS03	.18	74LS194	.69
74LS04	.16	74LS195	.69
74LS05	.18	74LS196	.59
74LS08	.18	74LS197	.59
74LS09	.18	74LS221	.59
74LS10	.16	74LS240	.69
74LS11	.22	74LS241	.69
74LS12	.22	74LS242	.69
74LS13	.26	74LS243	.69
74LS14	.39	74LS244	.69
74LS15	.26	74LS245	.79
74LS20	.17	74LS247	.75
74LS21	.22	74LS248	.89
74LS22	.22	74LS249	.99
74LS26	.23	74LS251	.49
74LS27	.23	74LS253	.49
74LS28	.26	74LS256	1.79
74LS30	.17	74LS257	.39
74LS32	.18	74LS258	.49
74LS33	.28	74LS259	1.29
74LS37	.26	74LS260	.49
74LS38	.26	74LS261	1.49
74LS40	.17	74LS266	.39
74LS42	.39	74LS273	.79
74LS47	.59	74LS275	1.95
74LS48	.69	74LS279	.39
74LS49	.69	74LS280	1.98
74LS51	.17	74LS283	.59
74LS54	.22	74LS290	.89
74LS55	.22	74LS293	.89
74LS63	.89	74LS295	.69
74LS73	.29	74LS298	.69
74LS74	.24	74LS299	1.49
74LS75	.29	74LS322	3.95
74LS76	.29	74LS323	2.49
74LS78	.49	74LS324	1.75
74LS83	.49	74LS348	1.29
74LS85	.49	74LS352	1.29
74LS86	.22	74LS353	1.29
74LS90	.39	74LS363	1.35
74LS91	.89	74LS364	1.95
74LS92	.49	74LS365	.39
74LS93	.39	74LS366	.39
74LS95	.49	74LS367	.39
74LS96	.49	74LS368	.39
74LS107	.34	74LS373	.79
74LS109	.36	74LS374	.79
74LS112	.29	74LS375	.95
74LS113	.34	74LS377	.79
74LS114	.34	74LS378	1.18
74LS122	.45	74LS379	.95
74LS123	.49	74LS385	3.90
74LS124	2.75	74LS386	.45
74LS125	.39	74LS390	1.19
74LS126	.39	74LS393	.79
74LS132	.39	74LS395	1.19
74LS133	.49	74LS396	1.89
74LS136	.39	74LS399	1.49
74LS137	.99	74LS424	3.95
74LS138	.39	74LS447	.95
74LS139	.39	74LS490	1.95
74LS145	.99	74LS540	1.49
74LS147	.99	74LS541	1.49
74LS148	.99	74LS624	1.95
74LS151	.39	74LS640	.99
74LS153	.39	74LS645	.99
74LS154	1.49	74LS668	1.49
74LS155	.59	74LS669	1.29
74LS156	.49	74LS670	.89
74LS157	.35	74LS674	14.95
74LS158	.29	74LS682	3.20
74LS160	.29	74LS683	3.20
74LS161	.39	74LS684	3.20
74LS162	.49	74LS685	3.20
74LS163	.39	74LS688	2.40
74LS164	.49	74LS689	3.20
74LS165	.65	74LS783	22.95
74LS166	.95	81LS95	1.49
74LS168	.95	81LS96	1.49
74LS169	.95	81LS97	1.49
74LS170	.85	81LS98	1.49
74LS173	.49	25LS2518	4.13
74LS174	.39	25LS2521	2.80
74LS175	.39	25LS2538	3.74
74LS181	1.49	25LS2569	2.80
74LS189	4.95	26LS31	1.95
74LS190	.49	26LS32	1.95

Z-80

2.5 MHz

Z80-CPU	1.79
Z80-CTC	1.85
Z80-DART	4.95
Z80-DMA	4.95
Z80-PIO	1.85
Z80-SIO/0	4.95
Z80-SIO/1	4.95
Z80-SIO/2	4.95
Z80-SIO/9	4.95

4.0 MHz

Z80A-CPU	1.89
Z80A-CTC	1.95
Z80A-DART	5.95
Z80A-DMA	5.95
Z80A-PIO	1.95
Z80A-SIO/0	5.95
Z80A-SIO/1	5.95
Z80A-SIO/2	5.95
Z80A-SIO/9	5.95

6.0 MHz

Z80B-CPU	4.95
Z80B-CTC	8.95
Z80B-PIO	8.95
Z80B-DART	14.95
Z80B-SIO/0	12.95
Z80B-SIO/2	12.95

ZILOG

Z6132	19.95
Z8671	19.95

6500

1.0 MHz

6502	2.79
65C02(cmos)	12.95
6504	6.95
6505	8.95
6507	9.95
6520	1.95
6522	4.95
6526	26.95
6532	6.95
6545	6.95
6551	5.95
6561	19.95
6581	34.95

2.0 MHz

6502A	2.95
6520A	2.95
6522A	5.95
6532A	11.95
6545A	7.95
6551A	6.95

3.0 MHz

6502B	6.95

CLOCK CIRCUITS

MM5369	1.95
MM5369-EST	1.95
MM58167	12.95
MM58174	11.95
MSM5832	2.95

6800

68000-8	9.95
6800	1.95
6802	4.95
6803	9.95
6808	4.95
6809	5.95
6809E	5.95
6810	1.95
6820	2.95
6821	1.95
6828	14.95
6840	6.95
6843	19.95
6844	12.95
6845	4.95
6847	11.95
6850	1.95
6852	4.95
6860	7.95
6875	6.95
6883	22.95
68047	12.95
68488	14.95

6800=1 MHz

68B00	4.95
68B02	5.95
68B09E	7.95
68B09	7.95
68B10	3.95
68B21	4.95
68B40	14.95
68B45	8.95
68B50	3.95
68B54	7.95

68B00=2 MHz

8200

8202	9.95
8203	34.95
8205	3.29
8212	1.49
8214	3.85
8216	1.49
8224	2.25
8226	1.69
8228	3.49
8237	4.95
8237-5	6.95
8238	4.49
8243	2.95
8250	6.95
8251	1.95
8251A	2.49
8253	1.95
8253-5	2.49
8255	1.95
8255-5	2.49
8257	2.49
8257-5	2.95
8259	2.49
8259-5	2.95
8271	49.95
8272	4.95
8274	4.95
8275	26.95
8279	2.95
8279-5	3.49
8282	3.95
8283	3.95
8284	2.95
8286	3.95
8287	3.95
8288	4.95
8289	19.95
8292	12.95

8000

8031	9.95
8035	1.95
8039	2.95
8080	2.95
8085	2.95
8085A-2	4.95
8086	9.95
8087-2	139.95
8087	129.95
8088	7.95
8088-2	9.95
8089	49.95
8155	2.95
8155-2	3.95
8156	2.95
8185	26.95
8741	9.95
8748	9.95
8749	12.95
8755	19.95
80286	129.95
80287	229.95

UARTS

AY5-1013	3.95
AY3-1015	4.95
PT1472	1.95
TR1602	3.95
2350	4.95
2651	4.95
IM6402	6.95
IM6403	9.95
UPD7201	4.95
INS8250	6.95

DISK CONTROLLERS

1771	4.95
1791	9.95
1793	9.95
1795	12.95
1797	12.95
2791	19.95
2793	19.95
2795	29.95
2797	29.95
6843	19.95
8272	4.95
UPD765	4.95
MB8876	12.95
MB8877	12.95
1691	6.95
2143	6.95

MISC.

TMS99531	9.95
TMS99532	19.95
ULN2003	.79
3242	7.95
3341	4.95
MC3470	1.95
MC3480	8.95
MC3487	2.95
11C90	13.95
95H90	7.95
2513-001 UP	6.95
2513-002 LOW	9.95
AY5-2376	11.95
AY5-3600 STD	11.95
AY5-3600 PRO	11.95

JDR Microdevices
1224 S. Bascom Avenue, San Jose, CA 95128
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RETAIL STORE - 1256 S. BASCOM AVENUE
HOURS: M-W-F, 9-5 TU-TH, 9-9 SAT, 10-3

PLEASE USE YOUR CUSTOMER NUMBER WHEN ORDERING

TERMS: Minimum order $10.00. For shipping and handling include $2.50 for UPS Ground and $3.50 for UPS Air. Orders over 1 lb. and foreign orders may require additional shipping charges - please contact our sales department for the amount. CA. residents must include applicable sales tax. All merchandise is warranted for 90 days unless otherwise stated. Prices are subject to change without notice. We are not responsible for typographical errors. We reserve the right to limit quantities and to substitute manufacturer. All merchandise subject to prior sale.

ALL MERCHANDISE 100% GUARANTEED

CIRCLE 276 ON FREE INFORMATION CARD

ORDER TOLL FREE 800-538-5000 800-662-6279 (CA)

7400

7400	.19	7483	.50	74172	5.95
7401	.19	7485	.59	74173	.75
7402	.19	7486	.35	74174	.89
7403	.19	7489	2.15	74175	.89
7404	.19	7490	.39	74176	.89
7405	.25	7491	.40	74177	.75
7406	.29	7492	.50	74178	1.15
7407	.29	7493	.35	74179	1.75
7408	.24	7494	.65	74180	.75
7409	.19	7495	.55	74181	2.25
7410	.19	7496	.70	74182	.75
7411	.25	7497	2.75	74184	2.00
7412	.30	74100	2.29	74185	2.00
7413	.35	74105	1.14	74189	2.99
7414	.49	74107	.30	74190	1.15
7416	.25	74109	.45	74191	1.15
7417	.25	74110	.45	74192	.79
7420	.19	74111	.55	74193	.79
7421	.35	74116	1.55	74194	.85
7422	.35	74120	1.20	74195	.85
7423	.29	74121	.29	74196	.79
7425	.29	74122	.45	74197	.75
7426	.29	74123	.49	74198	1.95
7427	.29	74125	.45	74199	1.35
7428	.45	74126	.45	74221	1.35
7430	.19	74128	.55	74246	1.35
7432	.29	74132	.45	74247	1.25
7433	.45	74136	.50	74248	1.85
7437	.29	74141	.65	74249	1.95
7438	.29	74142	2.95	74251	.75
7439	.79	74143	5.95	74259	2.25
7440	.19	74144	2.95	74265	1.35
7442	.49	74145	.60	74273	1.95
7443	.65	74147	2.49	74276	1.25
7444	.69	74148	1.20	74278	3.11
7445	.69	74150	1.35	74279	.75
7446	.89	74151	.55	74283	2.00
7447	.89	74152	.65	74284	3.75
7448	.89	74153	.55	74285	3.75
7450	.19	74154	1.49	74290	.95
7451	.23	74155	.75	74293	1.29
7453	.23	74156	.65	74298	.85
7454	.23	74157	.55	74351	2.25
7460	.23	74159	1.65	74365	.65
7470	.35	74160	.85	74366	.65
7472	.29	74161	.69	74367	.65
7473	.34	74162	.85	74368	.65
7474	.33	74163	.69	74376	2.20
7475	.45	74164	.85	74390	1.75
7476	.35	74165	.85	74393	1.35
7480	.59	74166	1.00	74425	3.15
7481	1.10	74167	3.75	74426	.85
7482	.95	74170	1.65	74490	2.55

CMOS

4000	.25	4528	.79
4001	.25	4529	2.95
4002	.22	4531	.95
4006	.69	4532	1.95
4007	.22	4538	.95
4008	.89	4539	1.95
4009	.39	4541	1.29
4010	.39	4543	.99
4011	.19	4553	5.79
4012	.25	4555	.95
4013	.35	4556	.95
4014	.69	4558	2.45
4015	.29	4560	4.25
4016	.29	4569	3.49
4017	.49	4581	1.95
4018	.69	4582	1.95
4019	.35	4584	.69
4020	.59	4585	.75
4021	.69	45151	12.95
4022	.69	4702	12.95
4023	.25	4724	1.50
4024	.49	74C00	.29
4025	.25	74C02	.29
4026	1.49	74C04	.29
4027	.39	74C08	.29
4028	.65	74C10	.29
4029	.69	74C14	.59
4030	.39	74C20	.29
4034	1.45	74C30	.29
4035	.69	74C32	.35
4040	.69	74C42	1.19
4041	.75	74C48	1.79
4042	.59	74C73	.65
4043	.85	74C74	.59
4044	.69	74C76	.80
4045	1.98	74C83	1.95
4046	.69	74C85	1.49
4047	.69	74C86	.35
4048	.69	74C89	4.50
4049	.29	74C90	1.19
4050	.29	74C93	1.19
4051	.69	74C95	.99
4052	.69	74C150	5.75
4053	.69	74C151	2.25
4056	2.19	74C154	3.25
4060	.69	74C157	1.75
4066	.29	74C160	1.19
4068	.39	74C161	.99
4069	.19	74C162	1.19
4070	.29	74C163	.99
4071	.22	74C164	1.39
4072	.22	74C165	2.00
4073	.22	74C173	.79
4075	.25	74C174	.99
4076	.59	74C175	.99
4077	.29	74C192	1.49
4078	.29	74C193	1.49
4081	.22	74C195	1.39
4082	.22	74C200	5.75
4085	.79	74C221	1.75
4086	.89	74C240	1.89
4093	.49	74C244	1.89
4094	2.49	74C373	1.99
4098	1.49	74C374	1.99
4099	1.45	74C901	.39
14409	12.95	74C902	.85
14410	6.95	74C903	.85
14411	9.95	74C905	10.95
14412	6.95	74C906	.79
14419	4.95	74C907	.79
14433	14.95	74C908	2.00
14490	4.95	74C909	2.75
4502	.95	74C910	9.95
4503	.49	74C911	8.95
4507	.99	74C912	8.95
4508	1.49	74C914	1.95
4510	.69	74C915	1.19
4511	.69	74C917	8.95
4512	.79	74C918	2.75
4514	.99	74C922	4.49
4515	1.79	74C923	4.95
4516	.79	74C925	5.95
4518	.85	74C926	7.95
4519	.79	74C927	7.95
4520	.79	74C928	7.95
4521	4.99	80C95	.85
4522	.79	80C96	.95
4526	.79	80C97	.95
4527	1.95	80C98	1.20

HIGH SPEED CMOS

A new family of high speed CMOS logic featuring the speed of low power Schottky (8ns typical gate propagation delay), combined with the advantages of CMOS: very low power consumption, superior noise immunity, and improved output drive.

74HC00

74HC: Operate at CMOS logic levels and are ideal for new, all-CMOS designs.

74HC00	.59	74HC166	2.95
74HC02	.59	74HC174	.99
74HC04	.59	74HC175	.99
74HC08	.59	74HC193	1.25
74HC10	.59	74HC194	1.04
74HC11	.59	74HC195	1.09
74HC14	.79	74HC238	1.35
74HC20	.59	74HC240	1.89
74HC27	.59	74HC241	1.89
74HC30	.59	74HC242	1.89
74HC32	.69	74HC243	1.89
74HC51	.59	74HC244	1.89
74HC74	.75	74HC245	1.89
74HC75	.85	74HC251	.89
74HC85	.35	74HC257	.85
74HC86	.69	74HC259	1.39
74HC93	1.19	74HC273	1.89
74HC107	.79	74HC299	4.99
74HC109	.79	74HC367	.99
74HC112	.79	74HC368	.99
74HC125	1.19	74HC373	2.29
74HC132	1.19	74HC374	2.29
74HC133	.69	74HC390	1.39
74HC138	.99	74HC393	1.39
74HC139	.99	74HC4017	1.99
74HC148	1.19	74HC4020	1.39
74HC151	.89	74HC4024	1.59
74HC153	.89	74HC4040	1.39
74HC154	2.49	74HC4049	.89
74HC157	.89	74HC4050	.89
74HC158	.95	74HC4060	1.29
74HC161	1.15	74HC4075	.69
74HC163	1.15	74HC4511	2.39
74HC164	1.25	74HC4538	2.59

74HCT00

74HCT: Direct, drop-in replacements for LS TTL and can be intermixed with 74LS in the same circuit.

74HCT00	.69	74HCT193	1.39
74HCT02	.69	74HCT194	1.19
74HCT04	.69	74HCT195	1.29
74HCT08	.69	74HCT238	1.49
74HCT10	.69	74HCT240	2.19
74HCT11	.69	74HCT241	2.19
74HCT20	.69	74HCT242	2.19
74HCT27	.69	74HCT243	2.19
74HCT30	.69	74HCT244	2.19
74HCT32	.79	74HCT245	2.19
74HCT74	.85	74HCT251	1.09
74HCT75	.95	74HCT257	.99
74HCT86	.79	74HCT259	1.59
74HCT138	1.15	74HCT273	2.09
74HCT139	1.15	74HCT299	5.25
74HCT151	1.05	74HCT367	1.09
74HCT154	2.99	74HCT373	2.49
74HCT157	.99	74HCT374	2.49
74HCT158	.99	74HCT393	1.59
74HCT161	1.29	74HCT4017	2.19
74HCT164	1.39	74HCT4020	1.59
74HCT166	3.05	74HCT4040	1.59
74HCT174	1.09	74HCT4060	1.49
74HCT175	1.09	74HCT4538	2.59

VOLTAGE REGULATORS

TO-220 CASE PACKAGE

7805T	.49	7905T	.59
7808T	.49	7908T	.59
7812T	.49	7912T	.59
7815T	.49	7915T	.59
7824T	.49	7924T	.59

TO-3 CASE PACKAGE

7805K	1.39	7905K	1.49
7812K	1.39	7912K	1.49
7815K	1.39	7915K	1.49
7824K	1.39	7924K	1.49

TO-92 CASE PACKAGE

78L05	.49	79L05	.69
78L12	.49	79L12	.69
78L15	.49	79L15	.69

OTHER VOLTAGE REGS

78M05C	5volt	½amp	TO-220	.29
LM323K	5volt	3amp	TO-3	4.79
LM338K	Adj.	5amp	TO-3	3.95
78H05K	5volt	5amp	TO-3	7.95
78H12K	12volt	5amp	TO-3	8.95
78P05K	5volt	10amp	TO-3	14.95
UA78S40	FAIRCHILD		DIP	1.95

74S00

74S00	.29	74S134	.50	74S241	1.49
74S02	.29	74S135	.89	74S244	1.49
74S03	.29	74S138	.79	74S251	.79
74S04	.29	74S139	.79	74S253	.79
74S05	.29	74S140	.55	74S257	.79
74S08	.35	74S151	.79	74S258	.95
74S09	.40	74S153	.79	74S260	.79
74S10	.29	74S157	.79	74S273	2.39
74S11	.35	74S158	.95	74S274	19.95
74S15	.35	74S161	1.29	74S275	19.95
74S20	.29	74S162	1.95	74S280	1.95
74S22	.35	74S163	1.29	74S283	3.29
74S30	.29	74S168	3.95	74S287	1.69
74S32	.35	74S169	3.95	74S288	1.69
74S37	.69	74S174	.79	74S289	2.95
74S38	.69	74S175	.79	74S299	2.95
74S40	.29	74S180	11.95	74S301	6.95
74S51	.35	74S181	3.95	74S373	1.69
74S64	.40	74S182	2.95	74S374	1.69
74S65	.40	74S188	1.95	74S381	7.95
74S74	.49	74S189	1.95	74S387	1.95
74S85	.95	74S194	1.49	74S399	2.95
74S86	.35	74S195	1.49	74S412	2.98
74S112	.50	74S196	1.49	74S470	6.95
74S113	.50	74S197	1.49	74S471	4.95
74S114	.55	74S201	6.95	74S472	4.95
74S124	2.75	74S225	7.95	74S474	4.95
74S132	1.24	74S226	3.99	74S570	2.95
74S133	.45	74S240	1.49	74S571	2.95
				74S573	2.95

INTERFACE

8T26	1.29
8T28	1.29
8T95	.89
8T96	.89
8T97	.59
8T98	.89
DM8131	2.95
DP8304	2.29
DS8833	2.25
DS8835	1.99
DS8836	.99
DS8837	1.65
DS8838	1.30

INTERSIL

ICL7106	9.95
ICL7107	12.95
ICL7660	2.95
ICL8038	4.95
ICM7207A	5.59
ICM7208	15.95

EXAR

XR2206	3.75
XR2207	2.49
XR2208	1.79
XR2211	2.95
XR2240	1.95

LINEAR

LM301	.34	NE570	2.95
LM301H	.79	NE571	2.49
LM307	.40	NE590	2.50
LM308	.65	NE592	.98
LM308H	1.15	LM709	.59
LM309H	1.95	LM710	.75
LM309K	1.25	LM711	.79
LM310	1.75	LM723	.49
LM311	.59	LM723H	.55
LM311H	.89	LM733	.98
LM312H	1.75	LM741	.29
LM317K	3.49	LM741N-14	.35
LM317T	.95	LM741H	.40
LM318	1.49	LM747	.69
LM318H	1.59	LM748	.59
LM319H	1.90	LM1014	1.19
LM319	1.25	LM1303	1.95
LM320	see7900	LM1310	1.49
LM322	1.65	MC1330	1.69
LM323K	4.79	MC1349	1.89
LM324	.49	MC1350	1.19
LM329	.65	MC1358	1.69
LM331	3.95	MC1372	6.95
LM334	1.19	LM1414	1.59
LM335	1.40	LM1458	.49
LM336	1.75	LM1488	.49
LM337T	1.89	LM1489	.49
LM337K	3.95	LM1496	.85
LM338K	3.95	LM1558H	3.10
LM339	.59	LM1800	2.37
LM340	see7800	LM1812	8.25
LM348	.89	LM1830	3.50
LM350K	4.95	LM1871	5.49
LM350T	4.60	LM1872	5.49
LM358	.59	LM1877	3.52
LM359	1.79	LM1889	1.95
LM376	3.75	LM1896	1.75
LM377	1.95	ULN2003	.79
LM378	2.50	XR2206	3.75
LM379	4.50	LM2877	2.05
LM380	.89	LM2878	2.25
LM380N-8	1.10	LM2900	.85
LM381	1.60	LM2901	1.00
LM382	1.49	MPQ2907	1.95
LM383	1.95	LM2917	1.95
LM384	1.95	MC3487	2.95
LM386	.89	LM3900	.49
LM387	1.39	LM3905	1.25
LM389	1.35	LM3909	.98
LM390	1.95	LM3911	2.25
LM392	.59	LM3914	2.39
LM393	.45	LM3915	2.39
LM394H	4.60	LM3916	2.39
LM399H	5.00	MC4024	3.49
NE531	1.79	MC4044	3.99
NE555	.29	RC4136	1.25
NE556	.49	RC4151	3.95
NE558	1.29	LM4250	1.75
NE564	1.95	LM4500	3.25
LM565	.95	RC4558	.69
LM566	1.49	LM13600	1.49
LM567	.79	LM13700	1.45

H=TO-5 CAN, K=TO-3, T=TO-220

RCA

CA3023	2.75	CA3083	.99
CA3039	1.29	CA3086	.80
CA3046	.89	CA3089	1.95
CA3059	2.90	CA3096	1.69
CA3060	2.90	CA3130E	.99
CA3065	1.29	CA3140E	.79
CA3080	.89	CA3146	1.29
CA3081	.99	CA3160	1.19
CA3082	.99	CA3183	.99

TI

TL494	4.20	75365	1.95
TL496	1.65	75450	.59
TL497	3.25	75451	.39
75107	1.49	75452	.39
75108	1.49	75453	.39
75110	1.95	75454	.39
75150	1.95	75477	1.29
75154	1.95	75491	.79
75160	4.95	75492	.79
75188	1.25	75493	.89
75189	1.25	75494	.89

BI FET

TL066	.99	LF347	2.19
TL071	.69	LF351	.59
TL072	1.09	LF353	.59
TL074	1.95	LF355	.99
TL081	.59	LF356	.99
TL082	.99	LF357	.99
TL083	1.19	LF411	1.29
TL084	1.49	LF412	1.99

OPTO-ISOLATORS

4N26	.69	MCA-7	4.25
4N27	.69	MCA-255	1.69
4N28	.69	IL-1	1.25
4N33	.89	ILA-30	1.25
4N35	.89	ILQ-74	3.25
4N37	1.19	H11C5	1.25
MCT-2	.59	TIL-111	.99
MCT-6	1.29	TIL-113	1.29

DATA ACQUISTION

ADC0800	15.55	DAC0806	1.95
ADC0804	3.49	DAC0808	2.95
ADC0809	4.49	DAC1020	8.25
ADC0816	14.95	DAC1021	7.95
ADC0817	9.95	DAC1022	5.95
ADC0831	8.95	MC1408L6	1.95
DAC0800	4.49	MC1408L8	2.95

9000 SERIES

9304	.95
9316	1.00
9328	1.49
9334	2.50
9368	3.95
9401	9.95
9601	.75
9602	1.50
9637	2.95
96S02	1.95

SOUND CHIPS

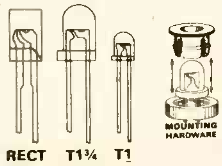
76477	3.95	AY3-8910	12.95
76489	8.95	AY3-8912	12.95
SSI-263	39.95	MC3340	1.49
		SP1000	39.00

TRANSISTORS

2N918	.50	2N3772	1.85
MPS918	.25	2N3903	.25
2N2102	.75	2N3904	.10
2N2218	.50	2N3906	.10
2N2218A	.50	2N4122	.95
2N2219	.50	2N4123	.25
2N2219A	.50	2N4249	.25
2N2222	.25	2N4304	.75
PN2222	.10	2N4401	.25
MPS2369	.25	2N4402	.25
2N2484	.25	2N4403	.25
2N2905	.50	2N4857	1.00
2N2907	.25	PN4916	.25
PN2907	.13	2N5086	.25
2N3055	.79	PN5129	.25
3055T	.69	PN5139	.25
2N3393	.30	2N5209	.25
2N3414	.25	2N6028	.35
2N3563	.40	2N6043	1.75
2N3565	.40	2N6045	1.75
PN3565	.25	MPS-A05	.25
MPS3638	.25	MPS-A06	.25
MPS3640	.25	MPS-A13	.40
PN3643	.25	MPS-A55	.25
PN3644	.25	MPU-131	.99
MPS3704	.15	TIP29	.65
MPS3706	.15	TIP31	.49
		TIP32	.49

DIFFUSED LEDS

		1-99	100-up
JUMBO RED	T1¾	.10	.09
JUMBO GREEN	T1¾	.14	.12
JUMBO YELLOW	T1¾	.14	.12
MOUNTING HDW	T1¾	.10	.09
MINI RED	T1	.10	.09
MINI GREEN	T1	.18	.15
MINI YELLOW	T1	.18	.15
RECT RED	2x5mm	.25	.22
RECT GREEN	2x5mm	.30	.27
RECT YELLOW	2x5mm	.30	.27



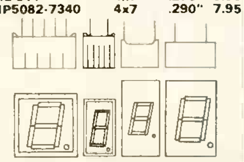
RECT T1¾ T1

LED DISPLAYS

FND-357(359)	CC	.362"	1.25
FND-500(503)	CC	.5"	1.49
FND-507(510)	CC	.5"	1.49
MAN-72	CA	.3"	.99
MAN-74	CC	.3"	.99
MAN-8940	CC	.8"	1.99
TIL-313	CC	.3"	.45
HP5082-7760	CC	.43"	1.29

HEX DISPLAYS WITH LOGIC

TIL-311	4x7	.270"	9.95
HP5082-7340	4x7	.290"	7.95


FND 500 FND-357 MAN 72 HP5082 7760

IC SOCKETS

	1-99	100
8 PIN ST	.11	.10
14 PIN ST	.11	.09
16 PIN ST	.12	.10
18 PIN ST	.15	.13
20 PIN ST	.18	.15
22 PIN ST	.15	.12
24 PIN ST	.20	.15
28 PIN ST	.22	.16
40 PIN ST	.30	.22
64 PIN ST	1.95	1.49
ST=SOLDERTAIL		
8 PIN WW	.59	.49
14 PIN WW	.69	.52
16 PIN WW	.69	.58
18 PIN WW	.99	.90
20 PIN WW	1.09	.98
22 PIN WW	1.39	1.28
24 PIN WW	1.49	1.35
28 PIN WW	1.69	1.49
40 PIN WW	1.99	1.80
WW=WIREWRAP		

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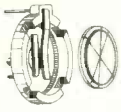

3 VOLT BATTERY $3.95
BATTERY HOLDER $1.49

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VOLTAGE	CONTACTS	FITS	PRICE
5 VDC	SPST REED	DIP	3.95
12 VDC	DPDT 2 AMP	DIP	3.95
6 VDC	6PDT 3 AMP	RELAY SOC	2.95
12 VDC	4PDT 3 AMP	RELAY SOC	3.95
24 VDC	DPDT 3 AMP	RELAY SOC	3.95
48 VDC	4PDT 3 AMP	RELAY SOC	3.95
120 VAC	4PDT 3 AMP	RELAY SOC	3.95

RF MODULATOR
ASTEC MODEL UM1082
* PRESET TO CHANNEL 3
* USE TO BUILD TV-COMPUTER INTERFACE
* +5 VOLT OPERATION

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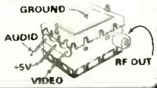

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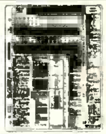

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* PLANNED FOR INSTANT ACCESS TO DATA
* TWO COMPREHENSIVE 8½ x 11" SIDES
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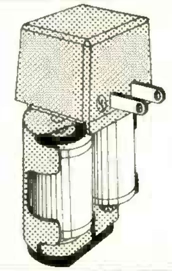

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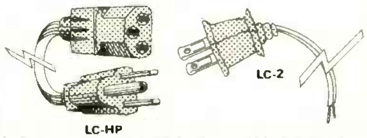

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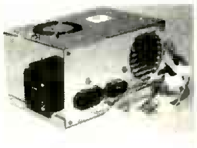

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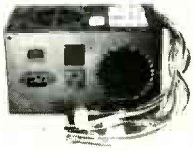

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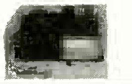

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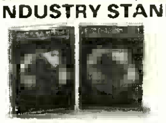

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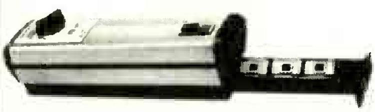

Model	Timer	Capacity Chip	Intensity (uW/Cm²)	Unit Price
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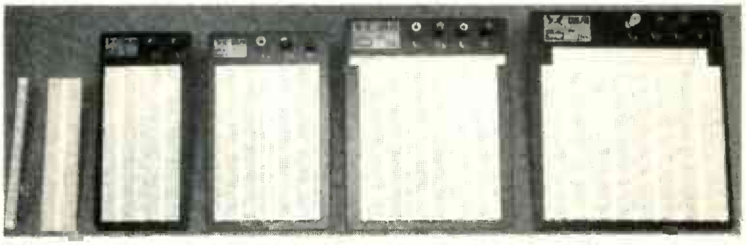

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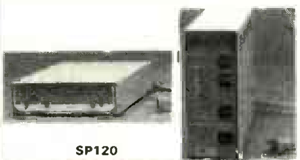
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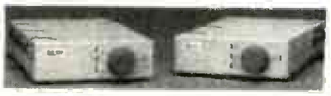

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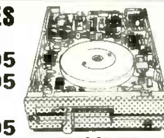
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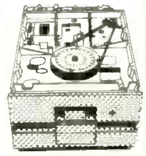
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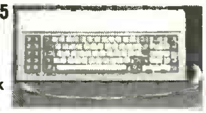

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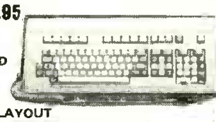

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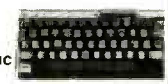

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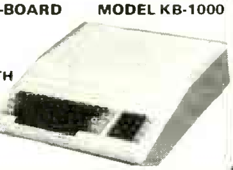

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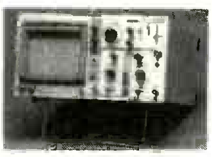

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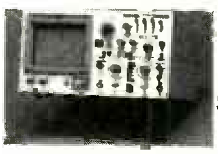

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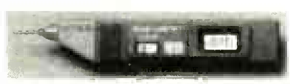

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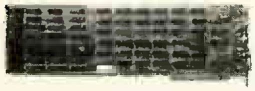

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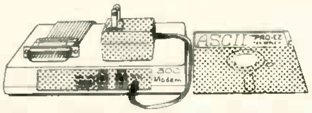

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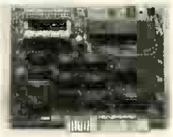

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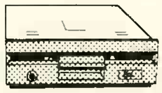

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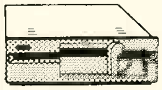

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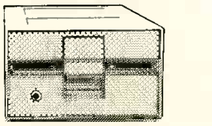

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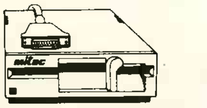

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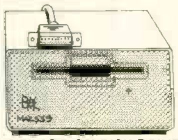

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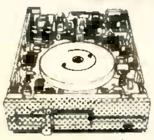

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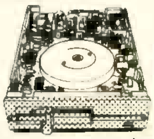

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